

**Missouri Department of Natural Resources
Water Protection Program**

Total Maximum Daily Loads (TMDLs)

for

**Hickory Creek
Daviness County, Missouri**

Completed: October 7, 2010

Approved: October 20, 2010

**Total Maximum Daily Load, or TMDL
for Hickory Creek
Pollutant: Unknown**

Name: Hickory Creek

Location: Daviess County near Jameson
and Coffey, Mo.

Hydrologic Unit Code (HUC): 10280101-160002

Water Body Identification (WBID): 442

Missouri Stream Class: C¹

Designated Beneficial Uses:

- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life
- Protection of Human Health (Fish Consumption)
- Whole Body Contact Recreation – Category B

Use that is impaired: Protection of Warm Water Aquatic Life

Location of Impaired Segment: Mouth to Section 11, T60N, R28W

Length of Impaired Segment: 1.5 miles²

Pollutant: Unknown

Source: None given

TMDL Priority Ranking: Medium



¹ Class C streams may cease flow in dry periods but maintain permanent pools which support aquatic life. See the Missouri water quality standards, or WQS, at 10 Code of State Regulations (CSR) 20-7.031(1)(F). The standards can be found online at www.sos.mo.gov/adrules/csr/current/10csr/10c20-7.pdf

²Effective Oct. 30, 2009, 10 CSR 20-7.031 Table H now lists the length for this segment as 2.8 miles.

1. Introduction and Background Information

This Hickory Creek Total Maximum Daily Load (TMDL) is being established in accordance with Section 303(d) of the Clean Water Act. This water quality limited segment near Jameson, Mo. in Daviess County is included on the U.S. Environmental Protection Agency (EPA) approved Missouri 2008 303(d) List of impaired waters with the pollutants of concern listed as unknown.

The purpose of a TMDL is to determine the pollutant loading a water body can assimilate without exceeding the water quality standards for that pollutant. The TMDL also establishes the pollutant load allocation necessary to meet the Missouri water quality standards established for each water body based on the relationship between pollutant sources and in-stream water quality conditions. The TMDL consists of a wasteload allocation, a load allocation, and a margin of safety. The wasteload allocation is the portion of the allowable pollutant load that is allocated to point sources. The load allocation is the portion of the allowable pollutant load that is allocated to nonpoint sources. The margin of safety accounts for the uncertainty associated with the model assumptions and data inadequacies. The model used to derive these TMDLs was completed by the EPA.

There are several Hickory Creeks in Missouri. This water quality limited segment lies in northwest Missouri, in north central Daviess County. The classified segment is listed as 1.5 miles long (see footnote #2, preceding page) and flows southwest and west before joining the Grand River about three miles northwest of Jameson. The Hickory Creek watershed area is 20.9 square miles with the upper most part of the watershed, which encompasses 5.2 square miles, in Harrison County to the north.

Per Missouri's Water Quality Standards regulation at 10 CSR 20-7.031, classified waters of the state must attain the Protection of Warm Water Aquatic Life designated use where designated. The combination of natural geology, topography, and land use in the former prairie region of the state where Hickory Creek is located is believed to have reduced the amount, and impaired the quality, of habitat for aquatic life. The creek was first documented as impaired during the Department's Visual/Benthic Low Flow Surveys in July 2000 and was reported in the revised "Monitoring Report on 26 Waters" (USEPA 2003). Evidence of impairment was primarily narrative rather than numeric, as indicated by the presence of duckweed and dense filamentous algae. These observations supported the case that nutrient enrichment was negatively impacting the stream. "Rocks darkened by manganese," which may indicate anoxic conditions, were also noted. However, no numeric data was collected to support the listing. In 2006-07, Versar, Inc., under contract to EPA, conducted a stressor identification study on the creek and found the aquatic community was impaired (Table 1). This study identified the stressors, or possible causes of impairment, as low dissolved oxygen levels, increased silt and sediment in the stream, poor habitat quality and low or altered flow regime. For more discussion of the study results, see Section 2.2.5. An additional study on Hickory Creek was conducted in 2008-09 by the department's Environmental Services Program, or ESP, examining both the aquatic invertebrate community and water quality parameters. When compared to bioreference streams, these sites showed no biological impairment during 2008-09. However, these were notably wet years, with more rainfall than normal.

Table 1. Stream Condition Scores for Hickory Creek

| Org Site | | Date | Score |
|-------------|----------------|-------------|-------|
| Versar Inc. | Hickory Cr.- 1 | Fall 2006 | 14 |
| Versar Inc. | Hickory Cr.- 1 | Spring 2007 | 12 |
| Versar Inc. | Hickory Cr.- 1 | Fall 2007 | 10 |
| Versar Inc. | Hickory Cr.- 2 | Spring 2007 | 4 |
| MDNR | Hickory Cr.- 2 | Fall 2008 | 16 |
| MDNR | Hickory Cr.- 2 | Spring 2009 | 18 |
| MDNR | Hickory Cr.- 3 | Fall 2008 | 20 |
| MDNR | Hickory Cr.- 3 | Spring 2009 | 18 |

Scores of 16 or greater indicate no impairment. See Figure 2 for site locations.

1.1 Soils

The soils in the Hickory Creek watershed fall into three main associations (USDA 1964). The Wabash-Nodaway association is found in the floodplain. The Nodaway soils are mainly well-drained, fine, sandy loam to silt loam. The Wabash soils are darker, contain more clay, and are more poorly drained. The soils of the Gara series have a moderately dark colored surface soil and are moderately well drained. These soils occur primarily on gentle to strong slopes where timber has encroached upon prairie. Most of the original surface soil has been lost to erosion from the Gara series acreage. The Grundy-Seymour association is on gently rolling to strongly rolling hills, with poorly to moderately well-drained soils formed from loess or till.

1.2 Land Use

Recent land use data for the Hickory Creek watershed indicates that 38.8 percent of the watershed is classified as grassland (which can include pastures), 35.9 percent is cropland and 21.6 percent is forest and woodland (Table 2 and Figure 1). Although only part of one town (population 140) is in the watershed, 2.9 percent is classified as urban and includes impervious surfaces like county roads and rooftops of large structures. Table 3 presents land use statistics within the Hickory Creek watershed by county (Daviss and Harrison). As shown in Figure 1, Hickory Creek is over 12 miles in length with only the lower 1.5 classified miles being listed as impaired.

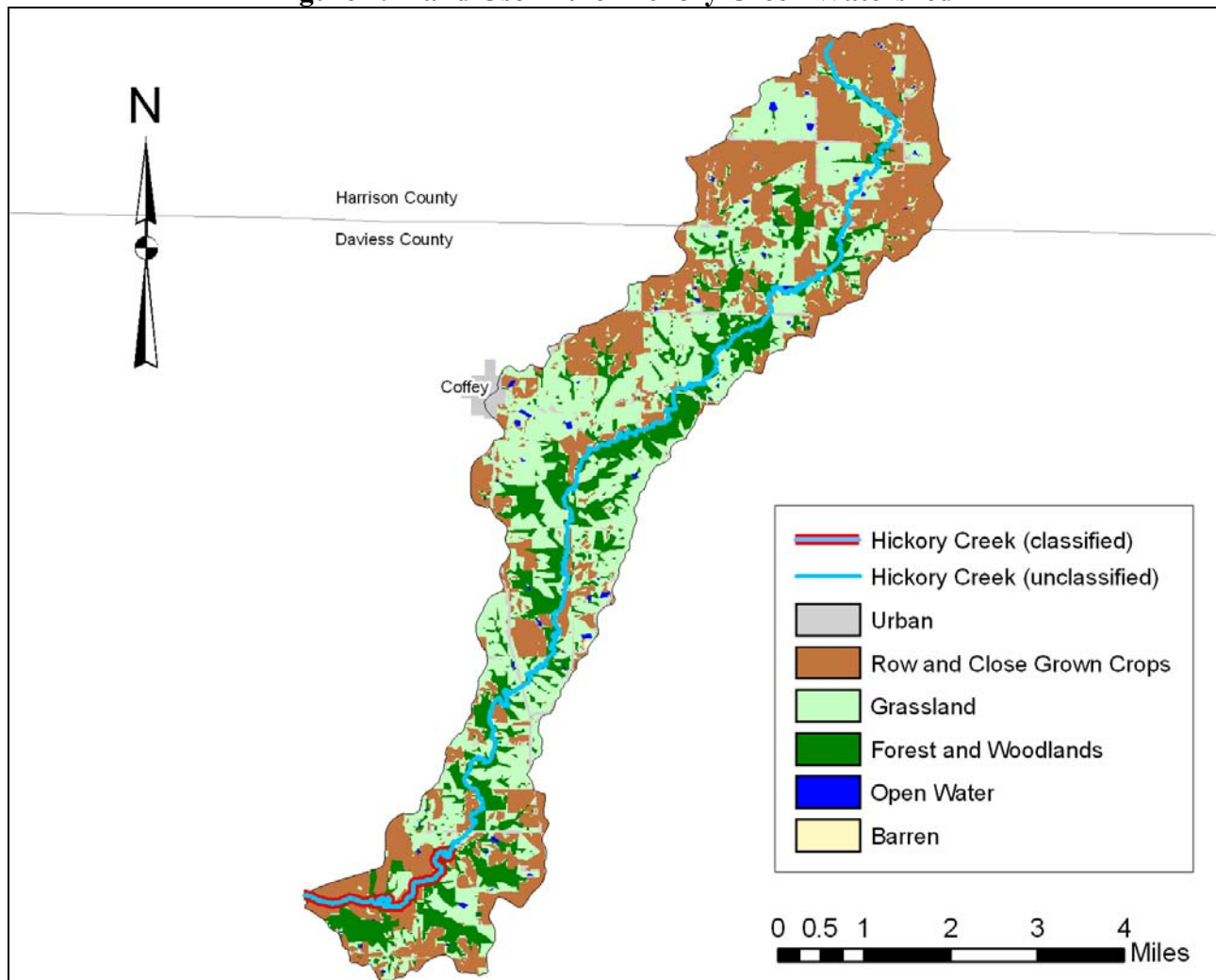
Table 2. Land Use/Land Cover in the Hickory Creek Watershed (MoRAP 2005)

| Land Use Type | Area - Acres | Area - Sq. Miles | Percentage |
|---------------------------|--------------|------------------|------------|
| Urban | 391 | 0.61 | 2.9 |
| Row and Close-grown Crops | 4,794 | 7.49 | 35.9 |
| Grassland | 5,191 | 8.11 | 38.8 |
| Forest and Woodland | 2,889 | 4.51 | 21.6 |
| Open Water | 91 | 0.14 | 0.7 |
| Barren | 10 | 0.01 | 0.1 |
| Totals | 13,366 | 20.87 | 100.0 |

Table 3. Land Use/Land Cover by County

| Land Use Type | Daviess County | | | Harrison County | | |
|---------------------------|----------------|--------------|--------------|-----------------|--------------|--------------|
| | Acres | Square Miles | Percentage | Acres | Square Miles | Percentage |
| Urban | 280 | 0.44 | 2.8 | 110 | 0.17 | 3.3 |
| Row and Close-grown Crops | 2,759 | 4.31 | 27.4 | 2040 | 3.19 | 61.7 |
| Grassland | 4,271 | 6.67 | 42.5 | 919 | 1.44 | 27.8 |
| Forest & Woodland | 2,675 | 4.18 | 26.6 | 212 | 0.33 | 6.4 |
| Open Water | 66 | 0.10 | 0.7 | 25 | 0.04 | 0.8 |
| Barren | 10 | 0.01 | 0.1 | 0 | 0.00 | 0.0 |
| Totals 10,061 | | 15.72 | 100.0 | 3306 | 5.17 | 100.0 |

Figure 1. Land Use in the Hickory Creek Watershed



1.3 Population

The population of the Hickory Creek watershed is not directly available; however, the rural population of the watershed can be estimated based on the proportion of the watershed that is located in Daviess and Harrison counties. The 2000 census data was used to conduct this analysis.

Daviess County covers an area of 563 square miles and has a population of 8,016. It incorporates eight towns (Altamont, Coffey, Gallatin, Jameson, Jamesport, Lock Springs, Pattonsburg and Winston) with a total urban population of 3,349. Since the rural population in Daviess County is 4,667 (total county population minus urban population) and the rural area of the Hickory Creek watershed in Davies County is approximately 15.72 square miles, the rural population of the watershed is estimated to be 130 (15.72 square miles divided by 563 square miles multiplied by 4,667 people).

Harrison County covers an area of 720 square miles and has a population of 8,850. It incorporates eight towns (Bethany, Blythedale, Cainsville, Eagleville, Gilman City, Mount Moriah, New Hampton and Ridgeway) with a total urban population of 5,413. Since the rural population in Harrison County is 3,437 (total county population minus urban population) and the rural area of the Hickory Creek watershed in Harrison County is approximately 5.17 square miles, the rural population of the watershed is estimated to be 25 (5.17 square miles divided by 720 square miles multiplied by 3,437 people).

2. Source Inventory

This section summarizes the available information on possible sources of pollution that could be impairing Hickory Creek. The two water quality studies show impairment of the aquatic community at low flow or drought conditions and a healthy aquatic community at higher flows. During both flow regimes, however, there are problems with excessive sedimentation and nutrients. These pollutants will be targeted by the TMDL (Section 3.5) and are the pollutants that will be addressed by the source inventory. Point (or regulated) pollutant sources are presented first, followed by nonpoint (or unregulated) sources.

2.1 Point Sources

The term “point source” refers to any discernible, confined and discrete conveyance, such as a pipe, ditch, channel, tunnel or conduit, by which pollutants are transported to a water body. Point sources are typically those regulated through the Missouri State Operating Permit program³. By law, point source also includes concentrated animal feeding operations, or CAFOs, which are facilities where animals are confined and fed and storm water runoff from Municipal Separate Storm Sewer Systems (MS4s). The Hickory Creek watershed contains one permitted CAFO, but there may be other smaller animal feeding operations in the watershed that are too small to require a permit.

The permitted facilities in the Hickory Creek watershed are listed in Table 4 and displayed in Figure 2. There are two facilities with general permits and one with a site specific permit within the watershed. All of the discharge outfalls for Continental Grain’s Campbell Creek Farm (MO-0118460) are in Gentry County and are not located in the Hickory Creek watershed. However, the facility does conduct water quality monitoring at several sites, including one on Hickory Creek identified as “outfall #15”. General

³ The Missouri State Operating Permitting program is Missouri’s program for administering the federal National Pollutant Discharge Elimination System (NPDES) program

permits (as opposed to site specific permits) are issued to activities that are similar enough to be covered by a single set of requirements. The general permits found within the Hickory Creek watershed are listed in Table 4 and start with MOG. These facilities do not discharge to the impaired stream, but do have storm water runoff during rain events. Figure 2 and Table 5 present a map of Hickory Creek in Daviess County with sampling sites and permitted facilities and sampling site locations, respectively.

Table 4. List of Permits in the Hickory Creek watershed

| Permit # | Facility Name | Type | Other | Design Flow (MGD) | Expire Date | Receiving Stream | Receiving Stream Class |
|-----------|-------------------------|---------------|-------|-------------------|-------------|--------------------|------------------------|
| MO0118460 | CGC CAMPBELL CREEK FARM | NON-MUNICIPAL | HOGS | 0.4570 | 20090415 | CAMPBELL CREEK* | U |
| MOG010475 | HICKORY CREEK FARMS | AFO-CAFO | HOGS | 0.0578 | 20110223 | HICKORY CREEK | U |
| MOG640140 | HARRISON COUNTY PWSD #2 | NON-MUNICIPAL | WATER | NONE | 20131023 | TRIB TO HICKORY CK | U |

*In Gentry County; MGD = Million Gallons Per Day

Illicit straight pipe discharges of household waste are also potential point sources in rural areas. These sources are discharges straight into streams or land areas and are different than illicitly connected sewers. There is no specific information on the number of illicit straight pipe discharges of household waste in the Hickory Creek watershed.

2.2 Nonpoint Sources

Nonpoint sources include all other categories not classified as point sources. Nonpoint sources potentially contributing to the impairment by unknown pollutants in the Hickory Creek watershed include runoff from agricultural areas, runoff from urban areas, onsite wastewater treatment systems and various sources associated with riparian habitat conditions. Each of these is discussed further in the following sections, along with the stressors identified in the Versar study mentioned in Section 1.

2.2.1 Runoff from Agricultural Areas

Lands used for agricultural purposes can be a source of nutrients, oxygen-consuming substances and sediment. Accumulation of nitrogen and phosphorus on cropland occurs from decomposition of residual crop material, fertilization with chemical and manure fertilizers, atmospheric deposition, wildlife excreta and irrigation water. There are 4,794 cropland acres in the watershed, which account for approximately 35.9 percent of the watershed's area (MoRAP, 2005). The Versar study found only low concentrations of phosphorus and nitrogen and minor amounts of algae, whose growth is spurred by nutrients. The Department water quality study found non-detectable levels of Total Phosphorous in the Spring 2009 survey, but elevated levels in the Fall 2008 survey. Total Nitrogen levels were elevated in both seasons. These data, along with data reported by permittees, indicate that nutrients are a factor in the impairment of Hickory Creek.

According to the 2006-2007 Versar study, excessive siltation is a problem throughout the entire impaired segment of Hickory Creek. Sources of sediment are varied, originating from both severely

eroding stream banks and agricultural fields throughout the watershed. Bottom substrates were primarily made up of fine particles such as silt, sand and/or clay.

Figure 2. Hickory Creek in Daviess County, Mo., with Sampling Sites and Permitted Facilities

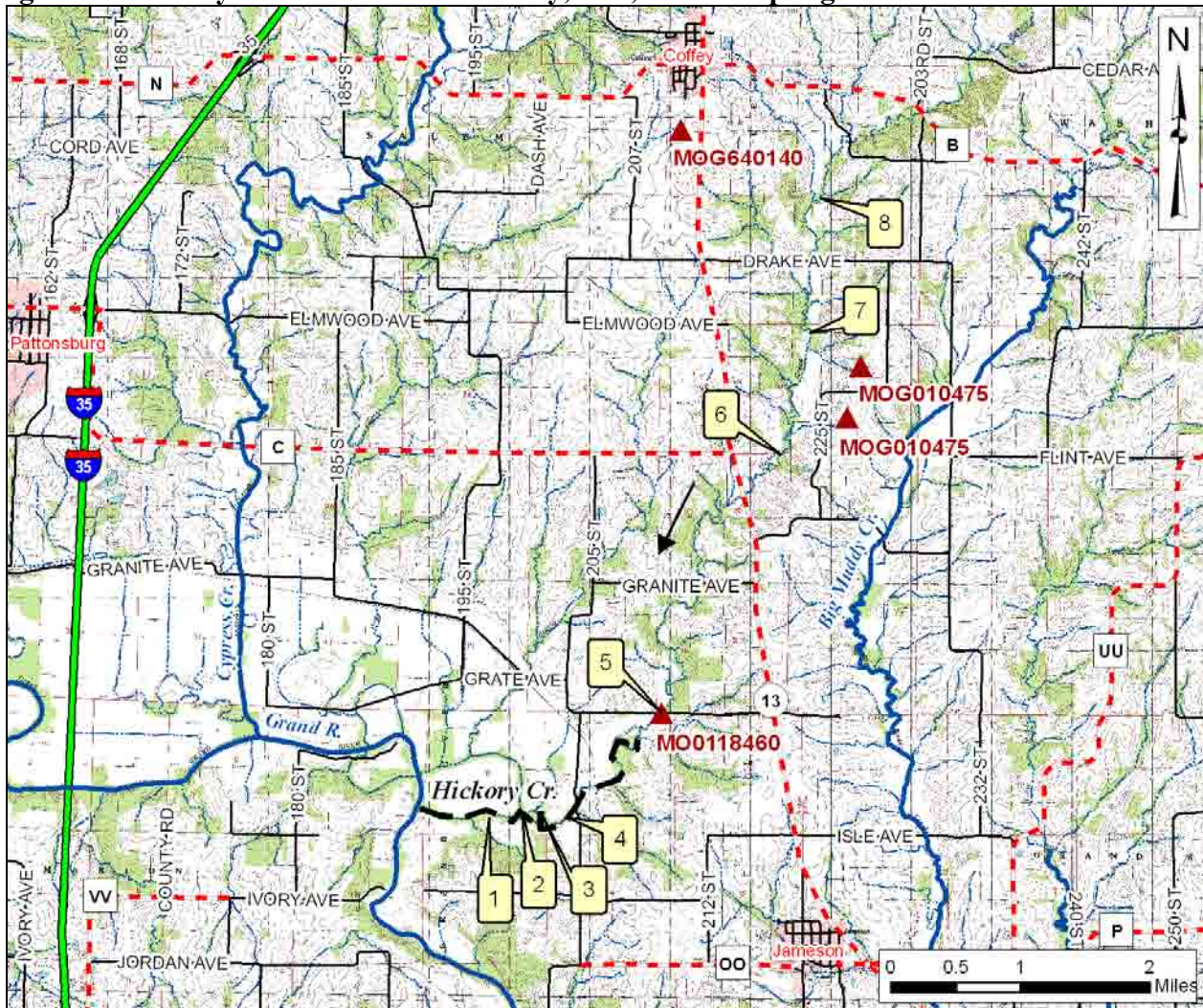


Table 5. Sample Site Index

| <i>Site Label</i> | <i>Site Number</i> | <i>Site Description</i> |
|-------------------|--------------------|---|
| 1 | 442/0.6 | Hickory Cr near mouth |
| 2 | | Hickory Cr MDNR bioassessment site 1, below 202 St. |
| 3 | 442/1.2 | Hickory Cr below 202 St |
| 4 | | Hickory Cr MDNR bioassessment site 2, below 202 St. |
| 5 | 442/1.5/0.3 | Hickory Cr at Harbor Ave |
| 6 | 442/1.5/3.9 | Hickory Cr downstream of CG Hickory Cr (Site 15) |
| 7 | 442/1.5/5.2 | Hickory Cr at CG Hickory Cr (Site 3) |
| 8 | 442/1.5/6.6 | Hickory Cr downstream of CG Hickory Cr (Site 19) |

Site number code: WBID/miles upstream of mouth/miles upstream of classified segment

Countywide data from the National Agricultural Statistics Service (USDA, 2009) were combined with the size of the Hickory Creek watershed to estimate there are 1,264 cattle in the watershed⁴. The cattle are most likely located on the approximately 5,191 acres of grassland in the watershed and runoff from these areas can be potential sources of nutrients, sediment from erosion, and other oxygen consuming substances. For example, animals grazing in pasture areas deposit manure directly upon the land surface and even though a pasture may be relatively large and animal densities low, the manure will often be concentrated near the feeding and watering areas in the field. These areas can quickly become barren of plant cover, increasing the possibility of erosion and contaminated runoff during a storm event. Based on Missouri's average recommended stocking rates of four acres per cow or 160 cows per square mile, the density of cattle in the Hickory Creek watershed (142-159 cattle per square mile) suggests they are not a potentially significant source of pollutants unless they are directly accessing the creek (Communication with Mark Kennedy, State Grazing Land Specialist, Texas County, Mo., 11/30/09).

The National Agricultural Statistics Service also reports there are 96,000 hogs and pigs in Daviess County and 45,000 hogs and pigs in Harrison County. Data was not available to estimate the number of these animals that might be located within the Hickory Creek watershed.

2.2.2 Runoff from Urban Areas

Storm water runoff from urban areas can also be a significant source of nutrients and other oxygen-consuming substances. Lawn fertilization can lead to high nutrient loads and pet wastes can contribute nutrients and other oxygen-consuming substances. For example, phosphorus loads from residential areas can be comparable to, or higher than, loading rates from agricultural areas (Reckhow et al., 1980; Athayde et al., 1983).

Storm water runoff from impervious surfaces such as parking lots and roofs is typically warmer than runoff from grassy and woodland areas. As this runoff is delivered to adjacent streams, it can lead to higher stream temperatures that lower the dissolved oxygen saturation capacity of the stream. Excessive discharge of suspended solids from urban areas (especially construction sites) can lead to streambed siltation problems and can convey nutrients and oxygen consuming substances to nearby streams. Leaking or illicitly connected sewers can also be a significant source of pollutant loads within urban areas.

Approximately 2.9 percent of the Hickory Creek watershed is classified as an urban area. This area includes county roads as well as part of the small town of Coffey (population 140) located at the edge of the watershed. Since the "urban" area is a small percent and the town is small, urban storm water runoff is not considered a significant contributor to the unknown impairment in Hickory Creek.

⁴ According to the National Agricultural Statistics Service, there were approximately 36,300 head of cattle in Daviess County in 2009 (www.nass.usda.gov/). According to the 2005 Missouri Resource Assessment Partnership land use and land cover data there are 228 square miles of grasslands in Daviess County. These two values result in a cattle density of approximately 159 cattle per square mile of grasslands. This density was then multiplied by the number of square miles of grassland in the Hickory Creek watershed (6.67) to estimate the number of cattle in the Daviess County part of the watershed (1,060). For Harrison County, the figures are 48,700 head of cattle in 342 square miles of grasslands which equates to 142 cattle per square mile of grassland. Multiplying that value by 1.44 square miles of grassland in the Harrison County portion of the watershed equals 204 cattle.

2.2.3 Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems (e.g., individual home septic systems) that are properly designed and maintained should not serve as a source of contamination to surface waters; however, onsite wastewater treatment systems do fail for a variety of reasons. When these treatment systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration), there can be adverse effects to surface waters. Failing septic systems are sources of nutrients that can reach nearby streams through both surface runoff and ground water flows.

The exact number of onsite wastewater systems in the Hickory Creek Watershed is unknown. However, as discussed in Section 1.3 of this document, the estimated rural population of the Hickory Creek watershed is approximately 155 persons. Based on this population and an average density of 2.5 persons per household, there may be approximately 62 onsite wastewater treatment systems in the watershed. While there is no available information on the percent of systems failing within the Hickory Creek watershed, EPA reports that the statewide failure rate of onsite wastewater systems in Missouri is 30 to 50 percent (USEPA, 2002). Because they are a source of nutrients and oxygen-consuming substances, onsite wastewater treatment systems are considered a possible source of pollutants to Hickory Creek.

2.2.4 Riparian Habitat Conditions

Riparian⁵ habitat conditions can also have a strong influence on the health of a stream. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in the detention, removal and assimilation of excess nutrients, soil and other pollutants before they reach the stream. Therefore, a stream with good riparian habitat is better able to prevent erosion and moderate the impacts of high nutrient loads than is a stream with poor habitat. Wooded riparian buffers can also provide shading that reduces stream temperatures, which can increase the dissolved oxygen saturation capacity of the stream.

The Versar study noted in 2006 that the riparian buffer was in fairly good condition, but land use just beyond the buffer was primarily row crops. During subsequent visits, the field crew noted that a large portion of the riparian forest was being harvested, with all the large trees being removed, including those that were adjacent to the stream banks. This activity will likely result in negative impacts to the stream as the stream's banks will continue to destabilize. As the structural integrity of the stream's banks are compromised, increased sediment inputs to the stream will exacerbate the problem of sediments smothering benthic habitat. The loss of trees will also allow for the summer sun to hit the stream more directly, causing an increase in temperature and a potential decrease in dissolved oxygen levels.

The riparian land use data and information found in Tables 6 and 7 were developed in 2005, before the tree removal noted in the above paragraph. As indicated in Table 6, however, almost 22 percent of the land in the Hickory Creek mainstem riparian corridor is classified as grassland, which might include pasture areas (MoRAP, 2005). Grassland provides limited riparian habitat compared to wooded areas, very little shading, and can also be associated with livestock activity. Another seven percent of the riparian corridor is classified as cropland, which also provides limited habitat and shading and can be

⁵ A riparian corridor (or zone or area) is the linear strip of land running adjacent to a stream bank.

associated with high nutrient loads and erosion related to runoff from agricultural areas. In general, a lack of good riparian habitat conditions should be considered as one component of water quality problems in Hickory Creek.

Table 6. Classified + Unclassified Hickory Creek Riparian Buffer (30 meters)

| Land Use Type | Area - Acres | Area-Square Miles | Percentage |
|---------------------------|---------------------|--------------------------|-------------------|
| Urban | 2 | 0.00 | 0.6 |
| Row and Close-grown Crops | 27 | 0.04 | 6.7 |
| Grassland | 87 | 0.14 | 21.8 |
| Forest & Woodland | 283 | 0.44 | 70.6 |
| Open Water | 2 | 0.00 | 0.4 |
| Barren | 0 | 0.00 | 0.0 |
| Totals 401 | | 0.63 | 100.0 |

Table 7. Classified Only Hickory Creek Riparian Buffer (30 meters)

| Land Use Type | Area - Acres | Area-Square Miles | Percentage |
|---------------------------|---------------------|--------------------------|-------------------|
| Urban | 0 | 0.00 | 0.0 |
| Row and Close-grown Crops | 5 | 0.01 | 7.8 |
| Grassland | 5 | 0.01 | 8.1 |
| Forest & Woodland | 54 | 0.08 | 82.4 |
| Open Water | 1 | 0.00 | 1.7 |
| Barren | 0 | 0.00 | 0.0 |

2.2.5 Other Stressors

The Versar study, as noted in Section 1, identified the causes of impairment in Hickory Creek as low dissolved oxygen levels, increased silt and sediment in the stream, poor habitat quality and low flow regime. Each cause is at least in part linked to the flow conditions in the channel. These stressors can mostly be linked to the nonpoint sources discussed above: Any or all of these four sources can cause or contribute to low dissolved oxygen.

- Any or all of the four sources mentioned above can cause or contribute to low dissolved oxygen.
- Runoff from both urban and rural or agricultural lands and the riparian zone can contribute silt and sediment. The number one pollutant entering Missouri's waters is sediment, with about 59 million tons of soil eroding from Missouri's land each year⁶. Sedimentation occurs when wind or water runoff carries soil particles from an area and transports them to a stream or lake.

⁶Missouri Soil and Water Districts Commission, March 2003, Needs Assessment, Plan To Address Identified Needs & A Summary To Date, add a date when link is checked <http://www.dnr.mo.gov/env/swcp/2003%20needs%20assessment.pdf>.

Excessive sedimentation clouds the water, which reduces the amount of sunlight reaching aquatic plants, covers fish spawning areas and food supplies, and clogs the gills of fish. In addition, other pollutants like nitrogen, phosphorus, pathogens, and heavy metals are often attached to soil particles and move into streams with the sediment (AgNPS 2010).

- Northern Missouri streams do not have the habitat quality that streams in other areas of Missouri have (e.g. Ozark streams) and typically have silty, muddy bottoms rather than gravel and cobble. Much of the habitat for macroinvertebrates in these streams relies on woody debris (fallen trees), rootwads and grass and herbaceous plant roots along the banks. However, while these structures may typically make up for the lack of gravel and cobble substrate, they are mostly absent in Hickory Creek. Benthic conditions such as these limit the range and abundance of benthic macroinvertebrates that can survive in Hickory Creek, making silt/sediment and habitat quality important factors in the stream's biological impairment. In addition, minimal or absent riparian forest (as noted in section 2.2.4) can also adversely impact habitat quality in the creek.
- The low flow regime: The Versar study noted that one of the major probable causes of impairment in Hickory Creek was the exceedingly low flow. During the fall of both 2006 and 2007, the upper reaches of the stream (about two miles of the impaired segment) were completely dry and did not satisfy the definition of a Class C stream found in rule. During these periods, flow in the stream ceased by permanent pools did not exist which supported aquatic life. This may partly be the result of a dry period and little water available for ground water recharge, with rainfall totals for summer and fall 2006 being the second lowest since 1998. Also, total yearly rainfall was the lowest since 1998 (Weather Underground, 2006). Data were obtained from Chillicothe, Mo., the closest available weather station to the stream and are presented in Appendix A. Low flow conditions affect nutrient yields, sediment loads and dissolved oxygen levels, all of which can put stress on aquatic communities. Low water levels also limit the amount of available habitat for aquatic communities by reducing the amount of available water. While the flow regime was no longer low in 2008-09, there is no way to accurately predict what the flow regime in Hickory Creek will be in the future.

3. Applicable Water Quality Standards and Numeric Water Quality Targets

Missouri's Water Quality Standards at 10 CSR 20-7.031 contains three main components: designated beneficial uses, water quality criteria that protect those uses (both numeric and narrative), and antidegradation requirements. These three components collectively ensure the quality of Missouri's waters is protected and maintained.

3.1 Designated Beneficial Uses

The designated beneficial uses for Hickory Creek (WBID 0442) are as follows:

- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life
- Protection of Human Health (Fish Consumption)
- Whole Body Contact Recreation – Category B

Additional information regarding stream classifications and designated beneficial uses may be found at 10 CSR 20-7.031(1)(C) and Table H.

3.2 Impaired Use

The use that is impaired is the Protection of Warm Water Aquatic Life.

3.3 Antidegradation Policy

Missouri's Water Quality Standards include the EPA "three-tiered" approach to antidegradation, which can be found at 10 CSR 20-7.031(2):

Tier 1 – Protects existing uses and a level of water quality necessary to maintain and protect those uses. Tier I provides the absolute floor of water quality for all waters of the United States. Existing instream water uses are those uses that were attained on or after Nov. 28, 1975, the date of EPA's first Water Quality Standards Regulation.

Tier 2 – Protects and maintains the existing level of water quality where it is better than applicable water quality criteria. Before water quality in Tier 2 waters can be lowered, there must be an antidegradation review consisting of: (1) a finding that it is necessary to accommodate important economic and social development in the area where the waters are located; (2) full satisfaction of all intergovernmental coordination and public participation provisions; and (3) assurance that the highest statutory and regulatory requirements for point sources and best management practices for nonpoint sources are achieved. Furthermore, water quality may not be lowered to less than the level necessary to fully protect the "fishable/swimmable" uses and other existing uses.

Tier 3 – Protects the quality of outstanding national and state resource waters, such as waters of national and state parks, wildlife refuges and waters of exceptional recreational or ecological significance. There may be no new or increased discharges to these waters and no new or increased discharges to tributaries of these waters that would result in lower water quality.

3.4 Specific Criteria

Because Hickory Creek has been listed as impaired for unknown pollutants, no identifiable numeric criteria apply. However, all Missouri Streams are protected by the general criteria contained in Missouri's Water Quality Standards at 10 CSR 20-7.031(3). The particular criteria that apply to Hickory Creek state:

(A) Waters shall be free from substances in sufficient amounts to cause the formation of putrescent, unsightly, or harmful bottom deposits or prevent full maintenance of beneficial uses.

(C) Waters shall be free from substances in sufficient amounts to cause unsightly color or turbidity, offensive odor, or prevent full maintenance of beneficial uses.

(D) Waters shall be free from substances or conditions in sufficient amounts to result in toxicity to human, animal, or aquatic life.

(G) Waters shall be free from physical, chemical, or hydrologic changes that would impair the natural biological community.

3.5. Water Quality Targets

The cause of impairment to the aquatic community in Hickory Creek is unknown. The Versar water quality report identified low dissolved oxygen levels, increased silt and sediment in the stream, poor habitat quality and low flow regime as the stressors. The Department water quality study, conducted during wetter years, showed a healthy aquatic community and acceptable levels of dissolved oxygen. Hydrologic records are not available from which to determine what is a “normal” flow regime for this stream, nor what are all the factors affecting flow in Hickory Creek. Because TMDLs are not written to address habitat issues, the Hickory Creek TMDL must target water quality conditions that attain the protection of warm water aquatic life designated use. Load capacities must be developed to reduce those pollutants causing or contributing to the unknown impairment. Therefore, given the information derived from the Department and Versar water quality studies, this Hickory Creek TMDL will address sediment and nutrients. It should be noted that while Missouri does not yet have numeric criteria for nutrients in its Water Quality Standards, the department is in the process of developing criteria for these pollutants. During the interim, peer reviewed and approved ecoregion total nitrogen and total phosphorous values are available from which to set targets applicable to the ecoregion in which Hickory Creek resides (Table 8). Targeting sediment will ensure already limited in-stream habitat is protected from additional sedimentation, and targeting nutrients will ensure these pollutants do not cause or contribute to a dissolved oxygen impairment or conditions that would lead to a violation of the narrative criteria.

Table 8. Criteria used to develop TSS, TN and TP TMDLs*

| | TSS EDU Target (mg/L) | TN Ecoregion Criteria (mg/L) | TP Ecoregion Criteria (mg/L) |
|--|----------------------------------|---|---|
| EDU and Ecoregion Targets and Criteria | 10 | 0.855 | 0.092 |

*The TSS target is based upon the 25th percentile of the EDU condition calculated from all data available from 1997-2009 (see Appendix B) within the Central Plains/Grand/Chariton EDU in which Hickory Creek is located. TN and TP criteria are based on the 25th percentile of data for all seasons in Ecoregion 40. These values are calculated as the median of the four seasonal 25th percentiles of data within an ecoregion (USEPA 2000).

There are many quantitative indicators of sediment, such as total suspended solids (TSS), turbidity, and bedload sediment, which are appropriate to describe sediment in rivers and streams. TSS was selected as the numeric target for sediment in the TMDL because it enables the use of the available data, including permit conditions and monitoring data. To address nutrients, both total nitrogen and total phosphorus are selected because both nutrients are generally elevated by point and nonpoint sources.

4 Load Capacity

Load capacity is defined as the maximum pollutant load that a water body can assimilate and still attain water quality standards. This load is then divided among the point source (wasteload allocation, or WLA) and nonpoint source (load allocation or LA) contributions to the stream, with an allowance for an explicit margin of safety, or MOS. If the margin of safety is implicit, no numeric allowance is necessary. Load capacity can be expressed as the following equation:

$$\text{Load capacity} = \sum \text{WLA} + \sum \text{LA} + \text{MOS}$$

The wasteload allocation and load allocation are calculated by multiplying the appropriate flow in cubic feet per second, or cfs, by the appropriate pollutant concentration in mg/L. A conversion factor of 5.395 is used to convert the units (cfs and mg/L) to pounds per day (lbs/day).

$$(stream\ flow\ in\ cfs)(maximum\ allowable\ pollutant\ concentration\ in\ mg/L)(5.395) = load\ in\ lbs/day$$

Critical conditions must be considered when the load capacity is calculated. Without a known pollutant, the critical period is difficult to determine. Given that the stream was dry in the fall of both years, low flow periods could be considered the critical conditions. In this TMDL, load duration curves, or LDCs, have been created. These models cover all flow conditions, so a target and load can be determined for any and all flows.

4.1 Modeling for Total Suspended Solids and Nutrients

Dissolved oxygen concentrations in streams are determined by factors such as photosynthetic productivity, respiration (autotrophic and heterotrophic), reaeration and temperature. These factors are influenced by natural and anthropogenic conditions within a watershed. Generally, reaeration is based on the physical properties of the stream and on the capacity of water to hold dissolved oxygen. This capacity is mainly determined by water temperature with colder water having a higher saturation concentration for dissolved oxygen than warmer water. In a review of variables and their importance in dissolved oxygen modeling, Nijboer and Verdonchot (2004) categorized the impact of a number of variables on oxygen depletion. For this TMDL, the effects of temperature and the physical aspects of the stream itself were discounted. Even though the hydrological regime of historic prairie streams was modified by changes in land cover and channelization, manipulation of these parameters does not address a pollutant and so is not the goal of a TMDL. Pollutants which result in oxygen concentrations below saturation are:

- fine particle size of bottom sediment
- high nutrient levels (phosphorus and nitrogen)
- suspended particles of organic matter

Because these three pollutants vary to a large extent based on anthropogenic influences, they are appropriate targets for a TMDL written to address an impairment where the pollutant is unknown.

4.1.1 Total Suspended Solids

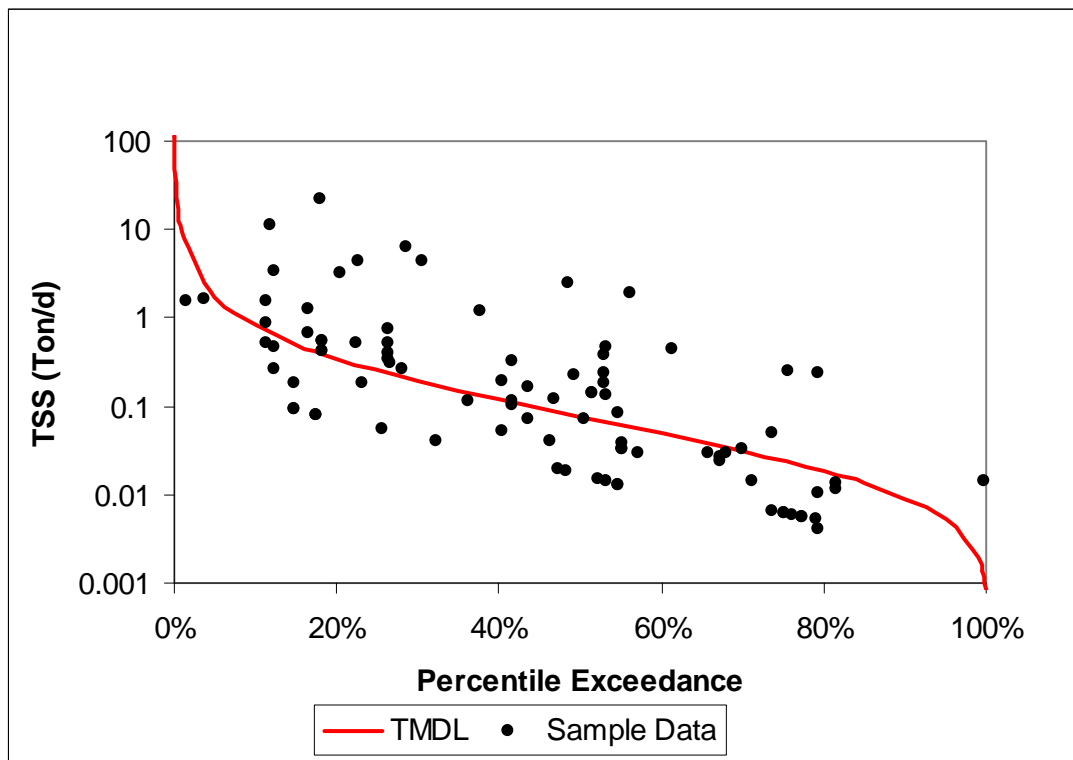
Since fine particle sized sediment and suspended particles of organic matter are derived from similar loading conditions of terrestrial and stream bank erosion, this TMDL will have total suspended solids (sediment) as one of its allocations. This target was derived based on a reference approach by targeting the 25th percentile baseload concentration (10 mg/L) of total suspended solids measurements⁷ in the geographic region where Hickory Creek is located (see Appendix C for a list of sites and data)⁸. For a full description of the development of total suspended solids targets using reference LDCs refer to Appendix B.

⁷ From U.S. Geological Survey TSS data, the 25th percentile of the data equals 10 mg/L.

⁸ The EPA ecoregion for Hickory Creek is Level III 40, the Central Irregular Plains. The Ecological Drainage Unit, or EDU, is the Central Plains/Grand/Chariton.

The load capacity for total suspended solids has been defined as a curve (LDC) over the range of flows for Hickory Creek, from high flows on the left to low flows on the right. Figure 3 shows the LDC for the total suspended solids, or TSS, TMDL for Hickory Creek (curve) as well as individual sample results (points) for this pollutant. Figure 3 is populated with data gathered by the Department and various permitted facilities in the watershed (See Appendix A.2).

Figure 3. TMDL Load Duration Curve for Total Suspended Solids in Hickory Creek



4.1.2 Nutrients

To address nutrient levels in Hickory Creek, the TMDL targeted EPA nutrient ecoregion reference concentrations for the Central Irregular Plains (Level III 40). These concentrations are 0.855 mg/L total nitrogen⁹ and 0.092 mg/L total phosphorus (USEPA 2001a and USEPA 2001b).

To develop load duration curves for total nitrogen and total phosphorus, a method similar to that used for total suspended solids was employed (Appendix C). First, total nitrogen and total phosphorus measurements were collected from U.S. Geological Survey, or USGS, sites in the vicinity of the impaired stream (See Tables C.2 and C.3 in Appendix C). These data were adjusted such that the median of the measured data was equal to the ecoregion reference concentration. This was accomplished by subtracting the difference of the data median and the reference concentration. Where the result was a negative concentration, the data point in question was replaced with the minimum

⁹Total Nitrogen is the sum of Total Kjeldahl nitrogen, ammonia as nitrogen, and nitrate plus nitrite as nitrogen.

concentration seen in the measured data. This resulted in a modeled data set which retained much of the original variability seen in the measured data. These modeled data were then regressed as instantaneous load versus flow. The resultant regression equation was used to create the load duration curves in Figures 4 and 5.

Figure 4. TMDL Load Duration Curve for Total Phosphorus in Hickory Creek

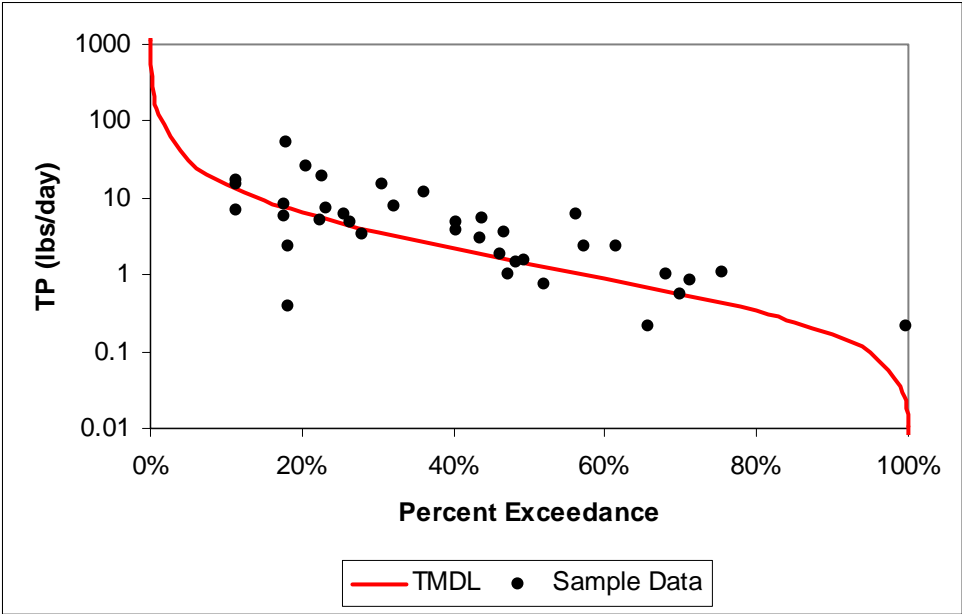
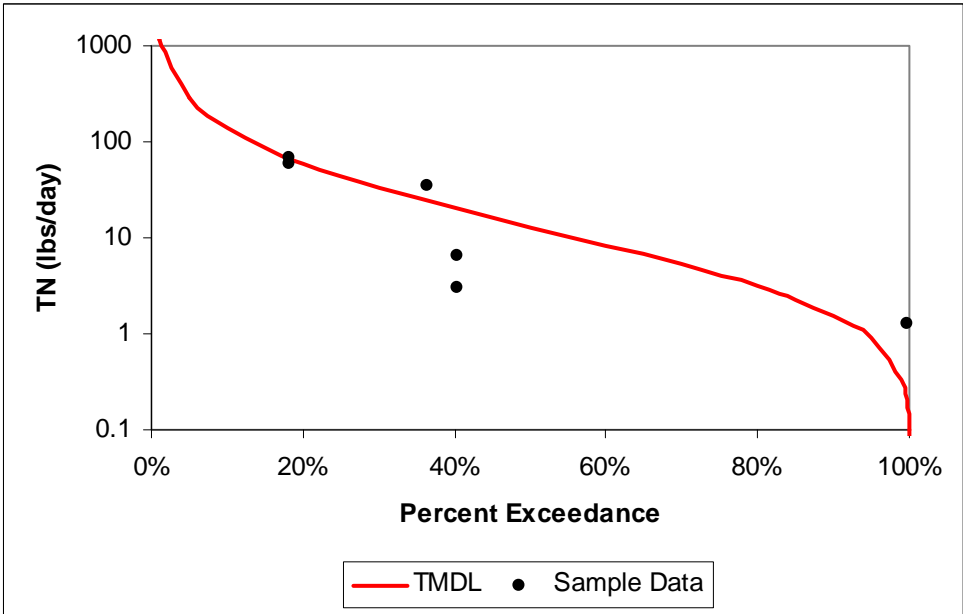


Figure 5. TMDL Load Duration Curve for Total Nitrogen in Hickory Creek



5 Wasteload Allocation

The wasteload allocation is the portion of the load capacity that is allocated to existing or future point sources of pollution. No point source in the Hickory Creek watershed has been determined to cause or contribute pollutants of concern to the impaired segment. The permitted facilities in the watershed discharge an insignificant volume of effluent and are unlikely to discharge during the targeted critical, low flow conditions. Therefore, loading from permitted facilities within the watershed will remain equal to existing permit limits and conditions. Because permitted facilities within the watershed will not cause or contribute pollutants of concern to the impaired segment, WLA values for these pollutants have been set at zero.

6 Load Allocation

The load allocation includes all existing and future nonpoint sources and natural background contributions (40 CFR § 130.2(g)). The load allocations for the Hickory Creek TMDL are for all nonpoint sources of total suspended solids (TSS), total nitrogen (TN), and total phosphorous (TP) and include loads from agricultural lands, runoff from urban areas, livestock, and failing onsite wastewater treatment systems. The load allocations in Table 9 are based on the load duration curves found in Figures 3, 4 and 5.

Table 9. Load Allocations for Hickory Creek – TN, TP and TSS

| Percentile flow exceedance | Flow (cfs) | TN TMDL (lbs/d) | TN LA (lbs/d) | TN sum WLA (lbs/d) | TP TMDL (lbs/d) | TP LA (lbs/d) | TP sum WLA (lbs/d) | TSS TMDL (T/d) | TSS LA (T/d) | TSS sum WLA (T/d) |
|----------------------------|------------|-----------------|---------------|--------------------|-----------------|---------------|--------------------|----------------|--------------|-------------------|
| 95% | 0.19 | 0.89 | 0.89 | 0.00 | 0.10 | 0.10 | 0.00 | 0.01 | 0.01 | 0.000 |
| 90% | 0.34 | 1.56 | 1.56 | 0.00 | 0.17 | 0.17 | 0.00 | 0.01 | 0.01 | 0.000 |
| 70% | 1.15 | 5.30 | 5.30 | 0.00 | 0.57 | 0.57 | 0.00 | 0.03 | 0.03 | 0.000 |
| 50% | 2.81 | 12.95 | 12.95 | 0.00 | 1.39 | 1.39 | 0.00 | 0.08 | 0.08 | 0.000 |
| 30% | 7.16 | 33.02 | 33.02 | 0.00 | 3.55 | 3.55 | 0.00 | 0.19 | 0.19 | 0.000 |
| 10% | 30.09 | 138.81 | 138.81 | 0.00 | 14.94 | 14.94 | 0.00 | 0.81 | 0.81 | 0.000 |
| 5% | 62.17 | 286.75 | 286.75 | 0.00 | 30.86 | 30.86 | 0.00 | 1.68 | 1.68 | 0.000 |

Note: TSS is in tons per day (t/d); *The MOS is implicit. See Section 7

7 Margin of Safety

A margin of safety is required in the TMDL calculation to account for uncertainties in scientific and technical understanding of water quality in natural systems. The margin of safety is intended to account for such uncertainties in a conservative manner. Based on EPA guidance, the margin of safety can be achieved through one of two approaches:

- (1) Explicit - Reserve a portion of the load capacity as a separate term in the TMDL.
- (2) Implicit - Incorporate the margin of safety as part of the critical conditions for the wasteload allocation and the load allocation calculations by making conservative assumptions in the analysis.

The margin of safety for the Hickory Creek TMDL is implicit and based on the conservative assumptions used in developing and applying the TMDL load duration curves. The use of ecoregion targets in lieu of national or state-wide nutrient targets serves to ensure that implementation will result in minimally impacted stream systems. The 25th percentile is considered a surrogate for establishing a reference population of pristine or minimally impacted systems (EPA 2000). TN and TP targets are conservative because they are based on the 25th percentile of all TN and TP data gathered from ecoregion 40. These data are not directly influenced by permitted dischargers. In the case of nutrients, the targets are the median calculated from the four seasonal 25th percentile values. As a result, both high concentrations seen during the periods of spring runoff and winter flow from snowmelt, and low concentrations seen during low flow conditions in both summer and fall, do not effectively affect the annual reference targets. In the case of sediment, the approach used was to target the 25th percentile of all concentration data available in the Central Plains/Grand/Chariton EDU in which Hickory Creek is located (see Appendix B). The use of these refined and/or EDU specific data ensures that all local geological and landscape conditions are addressed in this TMDL.

8 Seasonal Variation

Federal regulations at 40 CFR §130.7(c)(1) require that TMDLs take into consideration seasonal variation in applicable standards. The Hickory Creek TMDL takes seasonal variation into account through the use of load duration curves. Load duration curves represent the allowable pollutant load under different flow conditions and across all seasons. The results obtained using the load duration curve method are more robust and reliable over all flows and seasons when compared with those obtained under critical low-flow conditions.

9 Monitoring Plans

The Department has not yet scheduled post-TMDL monitoring for Hickory Creek. The Department will, however, continue to routinely examine physical habitat, water quality, invertebrate community, and fish community data collected by other state and federal agencies. One example is the Resource Assessment and Monitoring Program administered by the Missouri Department of Conservation. This program randomly samples streams across Missouri on a five to six year rotating schedule.

10 Implementation

No implementation plan has been identified for Hickory Creek. While biological indices calculated following the 2008 – 2009 study by the Department indicate no impairment to the aquatic community, TMDL LDCs show that improvement can be made to levels of total suspended solids, total nitrogen and total phosphorus reaching the stream. The Versar study points out that erosion control plans for surrounding farmland could be created and implemented to reduce sediment loads reaching the stream. Efforts could also be made to maintain the forested buffers that protect Hickory Creek from runoff from nearby farm fields. In addition, where nutrient management plans are not already being implemented in the watershed, it would be beneficial to initiate them. While the Versar study also recommends investigating the cause of the low flow conditions, the Department study suggests that those conditions were caused naturally by drought. Comparing the Department and Versar biological studies suggests that increased flows contributed to an improved aquatic community and elevated dissolved oxygen levels. However, it is unknown if these wetter conditions will continue to persist.

11 Reasonable Assurance

The Department has the authority to issue and enforce Missouri State Operating Permits. For TMDLs that address point sources of pollution, effluent limits determined from TMDL wasteload allocations incorporated into a state permit, along with effluent monitoring reported to the Department, should provide a reasonable assurance that instream water quality standards will be met. In the case of Hickory Creek, however, there are no point source contributions to the impairment as found in Section 2.1.

In most cases, "Reasonable Assurance" in reference to TMDLs relates only to point sources. As a result, any assurances that nonpoint sources of possible pollutants contributing to a degraded aquatic community will implement measures to reduce their contribution in the future will not be found in this section. Instead, discussion of reduction efforts relating to nonpoint sources can be found in the "Implementation" section of this TMDL.

12 Public Participation

This water quality limited segment of Hickory Creek is included on the approved 2008 303(d) List of impaired waters for Missouri. The public notice period for the draft Hickory Creek TMDL was April 13 to May 28, 2010. Groups that received the public notice announcement included the Missouri Clean Water Commission, the Water Quality Coordinating Committee, Missouri Department of Conservation, Daviess County Commissioners, Harrison County Presiding Commissioner, Daviess County Soil and Water Conservation District, 11 local Stream Team volunteers and the two state legislators representing Daviess and Harrison counties. Also, the public notice, the Hickory Creek TMDL Information Sheet and this document were posted on the Department website, making them available to anyone with access to the Internet. No comments were received regarding this TMDL.

13 Administrative Record and Documentation

An administrative record on the Hickory Creek TMDL has been assembled and is being kept on file with the department. It includes the following:

Stressor Identification for Willow Branch, Long Branch, Hickory Creek & Indian Creek, Missouri. [2006-2007] May 2008. Versar, Inc., 9200 Rumsey Rd, Columbia, MD 21045. Prepared for U.S. EPA, Region 7, Kansas City, MO

Biological Assessment Report, Hickory Creek, Daviess County, Missouri, Sept. 2008 - March 2009, Department of Natural Resources, Environmental Services Program

Models and calculations for Load Duration Curves

Missouri State Operating Permits #MO-0118460, MO-G010475 and MO-G640140

All documents pertaining to the Public Notice (Information Sheet, PN announcement, StreamGram, press release, mailing lists, etc)

14 Appendices

Appendix A – Weather Statistics and Water Quality Data

Appendix B – Development of Suspended Sediment Targets using Reference Load Duration Curves

Appendix C – Development of Nutrient Targets using EPA Recommended Ecoregion Nutrient Criteria with Load Duration Curves

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_____. 2001b. Ambient Water Quality Criteria Recommendations: Rivers and Streams in Nutrient Ecoregion X. U.S. Environmental Protection Agency, Washington DC. EPA 822-B-001-016.

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_____. 2003. Responsiveness Summary to Public Comments: EPA Public Notice Regarding Changes to Missouri's 2002 Section 303(d) List. December 2003.

Weather Underground. 2006. "Weather History for Chillicothe, Missouri."

<http://www.weatherunderground.com/US/MO/Chillicothe/KCDJ.html#History>.

Data source: National Weather Service. December 20.

Appendix A

A.1. Weather statistics for Chillicothe, Missouri, June,1998 - October, 2007. All data from the National Weather Service (NWS).

Note: No data available for 2000.

| Month/Year | Precipitation (Inches) | Average Maximum Temperature °F | Average Minimum Temperature °F | Average Mean Temperature °F |
|------------|---------------------------|-----------------------------------|-----------------------------------|--------------------------------|
| Jun-1998 | 8.09 | 80 | 61 | 71 |
| Jul-1998 | 5.74 | 85 | 68 | 76 |
| Aug-1998 | 5.14 | 85 | 66 | 76 |
| Sep-1998 | 7.45 | 82 | 60 | 71 |
| Oct-1998 | 8.01 | 66 | 46 | 56 |
| Nov-1998 | 4.22 | 55 | 36 | 46 |
| Dec-1998 | 1.21 | 42 | 23 | 33 |
| Jan-1999 | 1.17 | 32 | 17 | 25 |
| Feb-1999 | 1.64 | 48 | 31 | 39 |
| Mar-1999 | 2.19 | 51 | 31 | 41 |
| Apr-1999 | 6.37 | 64 | 44 | 55 |
| May-1999 | 5.91 | 72 | 51 | 62 |
| Jun-1999 | 5.63 | 80 | 62 | 71 |
| Jul-1999 | 2.28 | 89 | 68 | 79 |
| Aug-1999 | 2.21 | 84 | 63 | 73 |
| Sep-1999 | 4.56 | 77 | 49 | 63 |
| Oct-1999 | 0.26 | 68 | 41 | 55 |
| Nov-1999 | 1.45 | 62 | 37 | 50 |
| Dec-1999 | 1.82 | 42 | 23 | 33 |
| Jan-2001 | 2.09 | 35 | 18 | 27 |
| Feb-2001 | 4.17 | 36 | 20 | 28 |
| Mar-2001 | 2.90 | 46 | 27 | 37 |
| Apr-2001 | 4.01 | 71 | 47 | 59 |
| May-2001 | 9.38 | 73 | 55 | 64 |
| Jun-2001 | 6.89 | 81 | 62 | 71 |
| Jul-2001 | 2.16 | 87 | 70 | 79 |
| Aug-2001 | 4.18 | 86 | 65 | 75 |
| Sep-2001 | 3.27 | 75 | 53 | 64 |
| Oct-2001 | 3.23 | 65 | 42 | 54 |
| Nov-2001 | 0.68 | 61 | 39 | 50 |
| Dec-2001 | 0.78 | 46 | 26 | 36 |
| Jan-2002 | 1.84 | 43 | 22 | 33 |
| Feb-2002 | 1.54 | 44 | 24 | 34 |
| Mar-2002 | 0.81 | 51 | 27 | 39 |
| Apr-2002 | 4.02 | 66 | 43 | 54 |
| May-2002 | 6.80 | 71 | 49 | 60 |
| Jun-2002 | 2.76 | 85 | 64 | 75 |
| Jul-2002 | 2.73 | 90 | 67 | 79 |
| Aug-2002 | 5.85 | 85 | 64 | 75 |
| Sep-2002 | 0.62 | 83 | 56 | 69 |

| Month/Year | Precipitation (Inches) | Average Maximum Temperature °F | Average Minimum Temperature °F | Average Mean Temperature °F |
|------------|---------------------------|-----------------------------------|-----------------------------------|--------------------------------|
| Oct-2002 | 2.84 | 60 | 39 | 50 |
| Nov-2002 | 0.29 | 50 | 29 | 39 |
| Dec-2002 | 0.01 | 45 | 23 | 34 |
| Jan-2003 | 0.28 | 35 | 14 | 25 |
| Feb-2003 | 0.55 | 38 | 17 | 28 |
| Mar-2003 | 0.88 | 53 | 29 | 41 |
| Apr-2003 | 5.21 | 66 | 44 | 55 |
| May-2003 | 2.97 | 73 | 51 | 62 |
| Jun-2003 | 4.96 | 80 | 58 | 69 |
| Jul-2003 | 4.13 | 90 | 66 | 78 |
| Aug-2003 | 4.83 | 91 | 66 | 78 |
| Sep-2003 | 4.29 | 75 | 50 | 63 |
| Oct-2003 | 1.59 | 69 | 43 | 56 |
| Nov-2003 | 1.88 | 51 | 32 | 42 |
| Dec-2003 | 2.64 | 41 | 27 | 34 |
| Jan-2004 | 0.41 | 33 | 16 | 25 |
| Feb-2004 | 0.41 | 39 | 20 | 30 |
| Mar-2004 | 5.39 | 54 | 36 | 45 |
| Apr-2004 | 2.38 | 66 | 43 | 55 |
| May-2004 | 5.06 | 76 | 56 | 66 |
| Jun-2004 | 3.80 | 79 | 59 | 69 |
| Jul-2004 | 5.38 | 83 | 64 | 73 |
| Aug-2004 | 7.21 | 79 | 60 | 69 |
| Sep-2004 | 3.00 | 80 | 55 | 67 |
| Oct-2004 | 5.22 | 65 | 46 | 56 |
| Nov-2004 | 2.06 | 52 | 37 | 45 |
| Dec-2004 | 0.57 | 42 | 23 | 33 |
| Jan-2005 | 2.37 | 34 | 21 | 28 |
| Feb-2005 | 2.61 | 46 | 27 | 37 |
| Mar-2005 | 1.42 | 53 | 30 | 42 |
| Apr-2005 | 1.28 | 67 | 44 | 56 |
| May-2005 | 2.23 | 75 | 50 | 63 |
| Jun-2005 | 7.39 | 85 | 64 | 74 |
| Jul-2005 | 0.93 | 90 | 65 | 77 |
| Aug-2005 | 4.02 | 88 | 65 | 76 |
| Sep-2005 | 1.86 | 82 | 58 | 70 |
| Oct-2005 | 3.55 | 67 | 44 | 55 |
| Nov-2005 | 1.55 | 55 | 33 | 44 |
| Dec-2005 | 1.49 | 35 | 21 | 28 |
| Jan-2006 | 2.20 | 47 | 30 | 38 |
| Feb-2006 | 0.09 | 43 | 20 | 31 |
| Mar-2006 | 4.49 | 53 | 34 | 44 |
| Apr-2006 | 3.40 | 71 | 46 | 59 |
| May-2006 | 1.29 | 74 | 52 | 64 |
| Jun-2006 | 2.10 | 86 | 61 | 73 |
| Jul-2006 | 2.89 | 91 | 68 | 79 |

| Month/Year | Precipitation (Inches) | Average Maximum Temperature °F | Average Minimum Temperature °F | Average Mean Temperature °F |
|------------|---------------------------|-----------------------------------|-----------------------------------|--------------------------------|
| Aug-2006 | 6.07 | 87 | 66 | 77 |
| Sep-2006 | 1.40 | 75 | 52 | 63 |
| Oct-2006 | 2.97 | 63 | 41 | 52 |
| Nov-2006 | 1.57 | 55 | 34 | 45 |
| Dec-2006 | 1.99 | 43 | 26 | 35 |
| Jan-2007 | 0.98 | 35 | 19 | 27 |
| Feb-2007 | 2.61 | 31 | 15 | 23 |
| Mar-2007 | 4.69 | 58 | 37 | 48 |
| Apr-2007 | 3.60 | 60 | 37 | 49 |
| May-2007 | 5.07 | 76 | 55 | 65 |
| Jun-2007 | 3.79 | 80 | 60 | 71 |
| Jul-2007 | 0.84 | 85 | 63 | 74 |
| Aug-2007 | 4.32 | 88 | 68 | 77 |
| Sep-2007 | 0.86 | 80 | 54 | 67 |
| Oct-2007 | 4.49 | 68 | 47 | 58 |

A.2. Data used in Populating Load Duration Curves.

All units in milligrams per liter, or mg/L, unless otherwise noted (see notes at end of table)

| Org | Site | Site Name | Year | Mo | Da | y | Flow C | DO | pH | SC | NH3N | TKN | NO3N | TN | PO4 | TP | TSS |
|------------|-------------|---|------|----|----|---|--------|----|-----|----|------|-----|------|----|-----|----|-------|
| ContiGroup | 442/1.5/5.2 | Hickory Cr. @ CG Hickory Cr. (Site 3) | 2001 | 1 | 17 | | 0.95 | 0 | 7.6 | | 0.99 | | 4.8 | | | | 7 |
| ContiGroup | 442/1.5/3.9 | Hickory Cr. DS of CG Hickory Cr. (Site 15) | 2001 | 1 | 17 | | 2.09 | 0 | 7.6 | | 0.99 | | 4.8 | | | | 7.8 |
| ContiGroup | 442/1.5/5.2 | Hickory Cr. @ CG Hickory Cr. (Site 3) | 2001 | 2 | 7 | | 9.22 | 0 | 7.8 | | 0.99 | | 2 | | | | 54 |
| ContiGroup | 442/1.5/3.9 | Hickory Cr. DS of CG Hickory Cr. (Site 15) | 2001 | 2 | 7 | | 1.67 | 0 | 7.7 | | 0.99 | | 2 | | | | 26 |
| ContiGroup | 442/1.5/6.6 | Hickory Cr. DS of CG Hickory Cr. (Site 19) | 2001 | 2 | 7 | | 15.7 | 0 | 7.6 | | 0.99 | | 2.1 | | | | 33 |
| ContiGroup | 442/1.5/3.9 | Hickory Cr. DS of CG Hickory Cr. (Site 15) | 2001 | 3 | 27 | | 0.56 | 2 | 7.3 | | 0.99 | | 1.2 | | | | 78 |
| ContiGroup | 442/1.5/5.2 | Hickory Cr. @ CG Hickory Cr. (Site 3) | 2001 | 4 | 25 | | 37.6 | 20 | 7.9 | | 0.99 | | 0.05 | | | | 25 |
| ContiGroup | 442/1.5/3.9 | Hickory Cr. DS of CG Hickory Cr. (Site 15) | 2001 | 4 | 25 | | 7.16 | 21 | 7.7 | | 0.99 | | 0.04 | | | | 9 |
| ContiGroup | 442/1.5/6.6 | Hickory Cr. DS of CG Hickory Cr. (Site 19) | 2001 | 4 | 25 | | 0.31 | 21 | 7.7 | | 0.99 | | 0.05 | | | | 8 |
| ContiGroup | 442/1.5/5.2 | Hickory Cr. @ CG Hickory Cr. (Site 3) | 2001 | 5 | 16 | | | | 7.7 | | | | | | | | 18 |
| ContiGroup | 442/1.5/3.9 | Hickory Cr. DS of CG Hickory Cr. (Site 15) | 2001 | 5 | 16 | | | | 5.7 | | | | | | | | 18 |
| ContiGroup | 442/1.5/3.9 | Hickory Cr. DS of CG Hickory Cr. (Site 15) | 2001 | 5 | 29 | | 1.26 | 18 | 7.4 | | 0.99 | | 0.32 | | | | 9 |
| ContiGroup | 442/1.5/5.2 | Hickory Cr. @ CG Hickory Cr. (Site 3) | 2001 | 6 | 26 | | 3.66 | 22 | 7.6 | | 0.99 | | 0.63 | | | | 16 |
| ContiGroup | 442/1.5/3.9 | Hickory Cr. DS of CG Hickory Cr. (Site 15) | 2001 | 6 | 26 | | 12.5 | 22 | 7.5 | | 0.99 | | 0.67 | | | | 29 |
| ContiGroup | 442/1.5/5.2 | Hickory Cr. @ CG Hickory Cr. (Site 3) | 2001 | 7 | 24 | | 0.71 | 28 | 7.4 | | 0.99 | | 0.05 | | | | 2.499 |
| ContiGroup | 442/1.5/3.9 | Hickory Cr. DS of CG Hickory Cr. (Site 15) | 2001 | 7 | 24 | | 0.84 | 27 | 7.7 | | 0.99 | | 0.33 | | | | 2.499 |
| ContiGroup | 442/1.5/5.2 | Hickory Cr. @ CG Hickory Cr. (Site 3) | 2001 | 8 | 27 | | 4.29 | 23 | 7.2 | | 0.99 | | 0.23 | | | | 2.499 |
| ContiGroup | 442/1.5/3.9 | Hickory Cr. DS of CG Hickory Cr. (Site 15) | 2001 | 8 | 27 | | 0.74 | 23 | 7.3 | | 0.99 | | 0.2 | | | | 2.499 |

| Org | Site | Site Name | Year | Mo | Da | y | Flow C | | DO | pH | SC | NH3N | TKN | NO3N | TN | PO4 | TP | TSS |
|------------|-------------|---|------|----|----|---|--------|----|----|-----|----|--------|-----|-------|----|---------|----|-------|
| ContiGroup | 442/1.5/5.2 | Hickory Cr. @ CG Hickory Cr. (Site 3) | 2001 | 9 | 26 | | 0.34 | 15 | | 6.8 | | 0.99 | | 0.07 | | | | 19 |
| ContiGroup | 442/1.5/3.9 | Hickory Cr. DS of CG Hickory Cr. (Site 15) | 2001 | 9 | 26 | | 0.23 | 15 | | 6.7 | | 0.99 | | 0.06 | | | | 2.499 |
| ContiGroup | 442/1.5/3.9 | Hickory Cr. DS of CG Hickory Cr. (Site 15) | 2001 | 10 | 30 | | 0.42 | 16 | | 7.7 | | 0.99 | | 0.015 | | | | 2.499 |
| ContiGroup | 442/1.5/5.2 | Hickory Cr. @ CG Hickory Cr. (Site 3) | 2001 | 11 | 28 | | 2.25 | 10 | | 7.3 | | 0.99 | | 0.015 | | | | 7 |
| ContiGroup | 442/1.5/3.9 | Hickory Cr. DS of CG Hickory Cr. (Site 15) | 2001 | 11 | 28 | | 1.01 | 9 | | 7.2 | | 0.99 | | 0.015 | | | | 6 |
| ContiGroup | 442/1.5/3.9 | Hickory Cr. DS of CG Hickory Cr. (Site 15) | 2001 | 12 | 11 | | 0.25 | 5 | | 8.2 | | 0.99 | | 0.015 | | | | 2.499 |
| ContiGroup | 442/1.5/3.9 | Hickory Cr. DS of CG Hickory Cr. (Site 15) | 2002 | 1 | 22 | | | 10 | | 7.2 | | 0.12 | | 0.099 | | 0.099 | | 5 |
| ContiGroup | 442/1.5/5.2 | Hickory Cr. @ CG Hickory Cr. (Site 3) | 2002 | 1 | 22 | | | 9 | | 7 | | 0.0499 | | 0.099 | | 0.05 | | 1.99 |
| ContiGroup | 442/1.5/6.6 | Hickory Cr. DS of CG Hickory Cr. (Site 19) | 2002 | 1 | 22 | | | 9 | | 7.3 | | 0.0499 | | 0.099 | | 0.05 | | 114 |
| ContiGroup | 442/1.5/3.9 | Hickory Cr. DS of CG Hickory Cr. (Site 15) | 2002 | 2 | 20 | | 2.42 | 5 | | 7.4 | | 0.0499 | | 0.2 | | 0.2 | | 5 |
| ContiGroup | 442/1.5/5.2 | Hickory Cr. @ CG Hickory Cr. (Site 3) | 2002 | 2 | 20 | | 2.15 | 5 | | 7.1 | | 0.0499 | | 0.2 | | 1.95 | | 5 |
| ContiGroup | 442/1.5/6.6 | Hickory Cr. DS of CG Hickory Cr. (Site 19) | 2002 | 2 | 20 | | 2.31 | 5 | | 7.1 | | 0.0499 | | 0.3 | | 2.19 | | 6 |
| ContiGroup | 442/1.5/3.9 | Hickory Cr. DS of CG Hickory Cr. (Site 15) | 2002 | 3 | 18 | | 0.65 | 9 | | 7.9 | | 0.0499 | | 0.099 | | 0.02499 | | 1.99 |
| ContiGroup | 442/1.5/5.2 | Hickory Cr. @ CG Hickory Cr. (Site 3) | 2002 | 3 | 18 | | 1.08 | 9 | | 7.6 | | 0.0499 | | 0.099 | | 0.099 | | 13 |
| ContiGroup | 442/1.5/6.6 | Hickory Cr. DS of CG Hickory Cr. (Site 19) | 2002 | 3 | 18 | | 1.08 | 10 | | 7.6 | | 0.0499 | | 0.099 | | 0.02499 | | 1.99 |
| ContiGroup | 442/1.5/5.2 | Hickory Cr. @ CG Hickory Cr. (Site 3) | 2002 | 4 | 23 | | 2.82 | 13 | | 8.2 | | 0.0499 | | 0.7 | | 0.06 | | 28 |
| ContiGroup | 442/1.5/5.2 | Hickory Cr. @ CG Hickory Cr. (Site 3) | 2002 | 5 | 31 | | 1.12 | 20 | | 7.5 | | 0.0499 | | 0.2 | | 0.07 | | 5 |
| ContiGroup | 442/1.5/5.2 | Hickory Cr. @ CG Hickory Cr. (Site 3) | 2002 | 6 | 26 | | 0.16 | 30 | | 7.3 | | 0.0499 | | 0.099 | | 0.69 | | 19 |
| ContiGroup | 442/1.5/3.9 | Hickory Cr. DS of CG Hickory Cr. (Site 15) | 2002 | 4 | 23 | | 3.85 | 14 | | 8.3 | | 0.0499 | | 0.7 | | 0.07 | | 15 |

| Org | Site | Site Name | Year | Mo | Da | y | Flow C | DO | pH | SC | NH3N | TKN | NO3N | TN | PO4 | TP | TSS |
|------------|-------------|---|------|----|----|---|--------|------|------|-----|------|--------|------|-------|-----|---------|------|
| ContiGroup | 442/1.5/3.9 | Hickory Cr. DS of CG Hickory Cr. (Site 15) | 2002 | 5 | 31 | | 0.72 | 21 | | 7.4 | | 0.0499 | | 0.4 | | 0.06 | 9 |
| ContiGroup | 442/1.5/3.9 | Hickory Cr. DS of CG Hickory Cr. (Site 15) | 2002 | 6 | 26 | | 0.77 | 30 | | 7.4 | | 0.0499 | | 0.099 | | 0.15 | 66 |
| ContiGroup | 442/1.5/6.6 | Hickory Cr. DS of CG Hickory Cr. (Site 19) | 2002 | 4 | 23 | | 5 | 15 | | 7.9 | | 0.0499 | | 0.6 | | 0.06 | 13 |
| ContiGroup | 442/1.5/6.6 | Hickory Cr. DS of CG Hickory Cr. (Site 19) | 2002 | 5 | 31 | | 0.01 | 14 | | 7.1 | | 0.12 | | 0.099 | | 0.02499 | 65 |
| ContiGroup | 442/1.5/6.6 | Hickory Cr. DS of CG Hickory Cr. (Site 19) | 2002 | 6 | 26 | | 0.14 | 30 | | 7.3 | | 0.0499 | | 0.099 | | 0.54 | 1.99 |
| ContiGroup | 442/1.5/5.2 | Hickory Cr. @ CG Hickory Cr. (Site 3) | 2002 | 5 | 21 | | | | 17 | | | | | | | | 4 |
| ContiGroup | 442/1.5/3.9 | Hickory Cr. DS of CG Hickory Cr. (Site 15) | 2002 | 5 | 21 | | | | 15.1 | | | | | | | | 1.99 |
| ContiGroup | 442/1.5/6.6 | Hickory Cr. DS of CG Hickory Cr. (Site 19) | 2002 | 5 | 21 | | | | 16.4 | | | | | | | | 1.99 |
| ContiGroup | 442/1.5/5.2 | Hickory Cr. @ CG Hickory Cr. (Site 3) | 2002 | 7 | 24 | | | 28 | | 7.4 | | 0.12 | | 0.099 | | 0.0299 | 8 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2004 | 4 | 28 | | 0.6 | 14 | 7.1 | 7.7 | | 0.0499 | | 0.099 | | 0.07 | 1.99 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2004 | 5 | 26 | | 21 | 16 | 11.7 | 7.8 | | 0.0499 | | 1.6 | | 0.31 | 135 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2004 | 6 | 23 | | 5.5 | 17.3 | 6.2 | 8.4 | | 0.0499 | | 0.6 | | 0.11 | 1.99 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2004 | 7 | 29 | | 0.5 | 19.7 | 6.5 | 7.8 | | 0.0499 | | 0.3 | | 0.07 | 11 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2004 | 8 | 26 | | 45 | 21.9 | 8.4 | 8.5 | | 0.0499 | | 0.4 | | 0.34 | 205 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2004 | 9 | 22 | | 1.1 | 20 | 7.9 | 7.7 | | 0.0499 | | 0.099 | | 0.09 | 11 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2004 | 10 | 28 | | 0.45 | 15 | 8.2 | 7.8 | | 0.0499 | | 0.099 | | 0.19 | 1.99 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2005 | 1 | 26 | | 1 | 2 | | 7.3 | | 0.13 | | 1.8 | | 0.38 | 92 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2005 | 2 | 25 | | 3.5 | 2 | | 8.1 | | 0.0499 | | 0.8 | | 0.06 | 9 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2005 | 3 | 21 | | 1.5 | 8 | | 8.2 | | 0.0499 | | 0.099 | | 0.05 | 1.99 |

| Org | Site | Site Name | Year | Mo | Da | y | Flow C | DO | pH | SC | NH3N | TKN | NO3N | TN | PO4 | TP | TSS |
|--------|-------------|---------------------------|------|----|----|---|--------|------|------|-----|--------|--------|--------|-------|------|------|------|
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2005 | 4 | 27 | | 3 | 9 | 15.5 | 8 | | 0.0499 | | 1.4 | | 0.09 | 26 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2005 | 5 | 23 | | 1.2 | 17 | 8.6 | 8.1 | | 0.0499 | | 0.4 | | 0.08 | 1.99 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2005 | 6 | 20 | | 1 | 19 | 5.4 | 8.1 | | 0.0499 | | 0.5 | | 0.08 | 16 |
| Versar | 442/0.6 | Hickory Cr near mouth | 2006 | 10 | 16 | | 0 | 8.8 | 3 | 7.4 | 496 | | | | | | |
| Versar | 442/0.6 | Hickory Cr near mouth | 2006 | 10 | 17 | | | | | | 0.0099 | 0.8 | 0.3 | 1.1 | 0.02 | 0.18 | 24 |
| Versar | 442/1.2 | Hickory Cr. bl. 202 St. | 2007 | 3 | 27 | | 0.02 | 18 | 9.2 | 8.3 | | 0.099 | 0.2499 | 0.24 | 0.24 | 0.06 | 0.14 |
| Versar | 442/0.6 | Hickory Cr near mouth | 2007 | 3 | 27 | | 0.04 | 19 | 8.5 | 7.4 | 532 | 0.099 | 0.2499 | 0.11 | 0.11 | 0.07 | 0.18 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2007 | 3 | 28 | | 1.6 | 18 | | 8.7 | | 0.0499 | | 0.099 | | 0.13 | 6 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2007 | 4 | 24 | | 0.4 | 14.3 | 13 | 7.8 | | 0.0499 | | 0.099 | | 0.12 | 6 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2007 | 5 | 23 | | 0.9 | 18.6 | 5.6 | 7.9 | | 0.0499 | | 0.099 | | 0.09 | 20 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2007 | 6 | 27 | | 0.03 | 23.6 | 7.6 | 7.4 | | 0.17 | | 0.099 | | 0.18 | 12 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2007 | 7 | 24 | | 0.08 | 21.8 | 4.5 | 7.7 | | 0.0499 | | 0.099 | | 0.36 | 7 |
| Versar | 442/0.6 | Hickory Cr near mouth | 2007 | 9 | 16 | | 0 | 13 | 6.6 | 7.1 | 359 | 0.0099 | 0.2499 | 0.099 | | 0.15 | 5 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2007 | 10 | 25 | | 0.2 | 6.6 | 13.5 | 7.7 | | 0.0499 | | 0.2 | | 0.2 | 5 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2007 | 12 | 21 | | 11.5 | 1 | | 7.9 | | 0.0499 | | 2.4 | | 0.16 | 9 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2008 | 1 | 30 | | 11 | 0.5 | | 7.9 | | 0.19 | | 1.8 | | 0.49 | 314 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2008 | 3 | 26 | | 5 | 7 | | 8.1 | | 0.0499 | | 0.7 | | 0.1 | 1.99 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2008 | 4 | 29 | | 15 | 8 | 7.8 | 8.1 | | 0.0499 | | 0.8 | | 0.15 | 27 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2008 | 5 | 29 | | 3.6 | 15 | 12.6 | 8 | | 0.0499 | | 0.9 | | 0.13 | 15 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2008 | 6 | 26 | | 320 | 22 | 10.8 | 7.7 | | 0.0499 | | 0.4 | | 0.67 | 567 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2008 | 7 | 30 | | 75 | 22.8 | 8.8 | 7.9 | | 0.0499 | | 0.3 | | 0.25 | 94 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor | 2008 | 8 | 29 | | 16.2 | 19.3 | 7.9 | 8.1 | | 0.0499 | | 0.099 | | 0.22 | 105 |

| Org | Site | Site Name | Year | Mo | Da | y | Flow | C | DO | pH | SC | NH3N | TKN | NO3N | TN | PO4 | TP | TSS |
|------|----------------------|---------------------------------------|------|----|----|---|------|------|------|-----|-----|--------|-----|-------|------|-----|-------|------|
| | | Ave. | | | | | | | | | | | | | | | | |
| MDNR | ?? | Below 202 St | 2008 | 9 | 25 | | 7.02 | 18.9 | 7.1 | 7.7 | 318 | 0.0499 | | 0.13 | 1.03 | | 0.24 | |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2008 | 9 | 26 | | 10 | 17.9 | 8.1 | 7.8 | | 0.0499 | | 0.099 | | | 0.24 | 14 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2008 | 10 | 30 | | 10 | 8.1 | 10.3 | 7.9 | | 0.0499 | | 0.099 | | | 0.09 | 4 |
| CGC | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2008 | 11 | 25 | | 7.8 | 2.1 | 12 | 8.2 | | 0.0499 | | 0.3 | | | 0.05 | 1.99 |
| MDNR | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2009 | 4 | 20 | | 3 | 16.6 | 10.5 | 8.4 | 398 | | | | | | | 9 |
| MDNR | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2009 | 3 | 11 | | 4 | 3.4 | 12.4 | 8.4 | 341 | | | | | | | 274 |
| MDNR | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2009 | 2 | 27 | | 4 | 2.1 | 12.5 | 8.5 | 323 | | | | | | | 277 |
| MDNR | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2009 | 2 | 18 | | 2.34 | 1.7 | 12.3 | | 554 | | | | | | | 12 |
| MDNR | 442/1.2 | Hickory Cr. bl. 202 St. | 2009 | 4 | 8 | | 6.75 | 10.1 | 11.7 | 8.4 | 472 | 0.015 | | 0.52 | 0.77 | | 0.005 | 11 |
| MDNR | 442/ less than above | Hickory Cr. Further DS of bl. 202 St. | 2009 | 4 | 8 | | 6.75 | 11.2 | 11.7 | 8.2 | 470 | 0.015 | | 0.5 | 0.87 | | 0.03 | 14 |
| MDNR | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2009 | 5 | 6 | | 2 | 16.6 | 9.2 | 8.3 | 513 | | | | | | | 14 |
| MDNR | 442/1.5/0.3 | Hickory Cr. @ Harbor Ave. | 2009 | 5 | 26 | | 8 | 18.7 | 8.1 | 8.3 | 407 | | | | | | | 204 |

Note: CGC=Continental Grain Company; C=Temperature in degrees Celsius, DO=dissolved oxygen, SC=specific conductivity in micromohs/centimeter ($\mu\text{mohs/cm}$), NH3N=ammonia as nitrogen, TKN=total Kjeldahl nitrogen, NO3N=nitrate plus nitrite as nitrogen, TN=total nitrogen, PO4=phosphate, TP=total phosphorus, TSS=total suspended solids

Appendix B

Development of Suspended Sediment Targets using Reference Load Duration Curves

Overview

This procedure is used when a lotic¹⁰ system is placed on the 303(d) List for a pollutant and the designated use being addressed is aquatic life. In cases where pollutant data for the impaired stream is not available a reference approach is used. The target for pollutant loading is the 25th percentile calculated from all data available within the ecological drainage unit (EDU) in which the water body is located. Additionally, it is also unlikely that a flow record for the impaired stream is available. If this is the case, a synthetic flow record is needed. In order to develop a synthetic flow record calculate an average of the log discharge per square mile of USGS gaged rivers for which the drainage area is entirely contained within the EDU. From this synthetic record develop a flow duration from which to build a load duration curve for the pollutant within the EDU.

From this population of load durations follow the reference method used in setting nutrient targets in lakes and reservoirs. In this methodology the average concentration of either the 75th percentile of reference lakes or the 25th percentile of all lakes in the region is targeted in the TMDL. For most cases available pollutant data for reference streams is also not likely to be available. Therefore follow the alternative method and target the 25th percentile of load duration of the available data within the EDU as the TMDL load duration curve. During periods of low flow the actual pollutant concentration may be more important than load. To account for this during periods of low flow the load duration curve uses the 25th percentile of EDU concentration at flows where surface runoff is less than 1 percent of the stream flow. This result in an inflection point in the curve below which the TMDL is calculated using load calculated with this reference concentration.

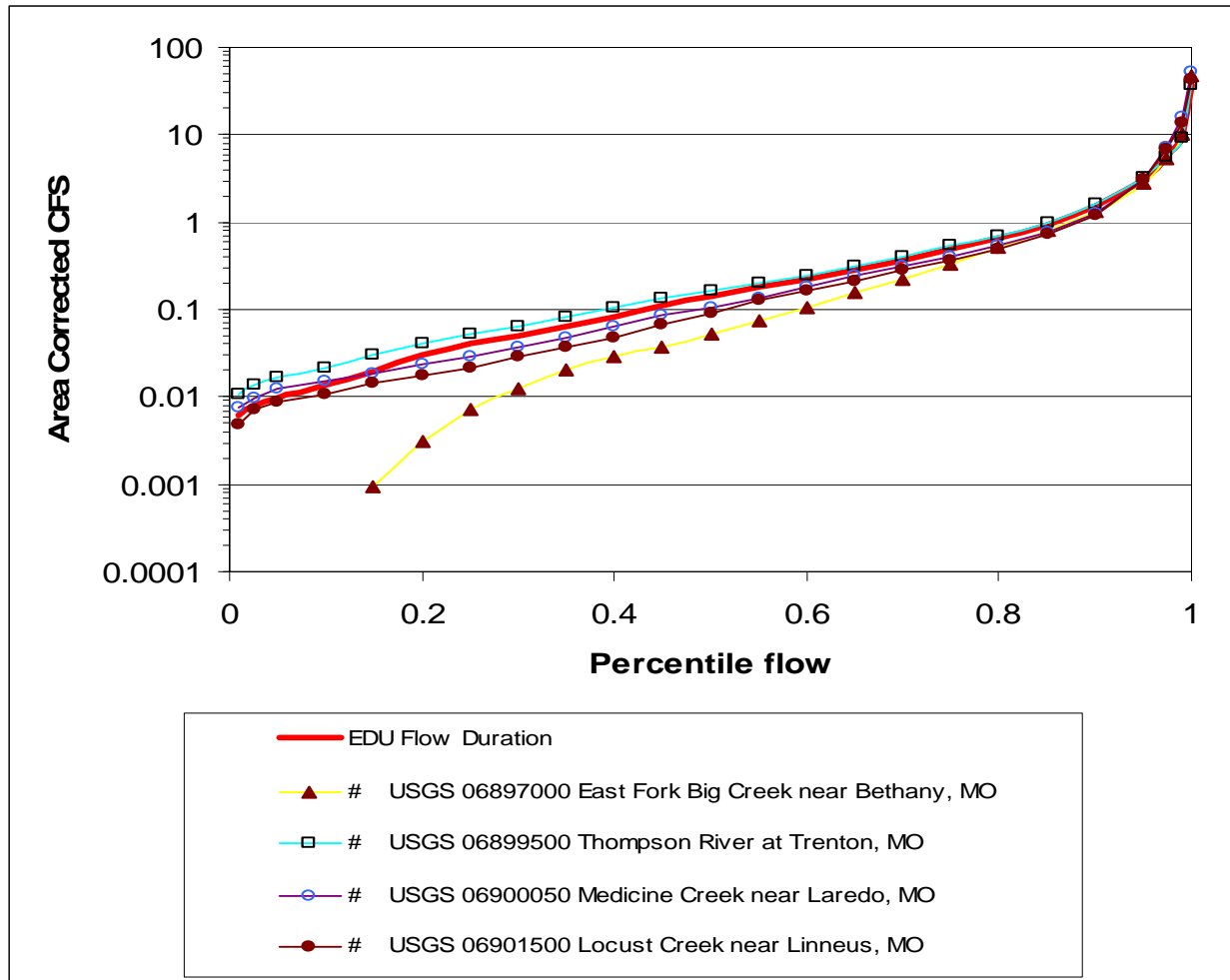
Methodology

The first step in this procedure is to locate available pollutant data within the EDU of interest. These data along with the instantaneous flow measurement taken at the time of sample collection for the specific date are recorded to create the population from which to develop the load duration. Both the date and pollutant concentration are needed in order to match the measured data to the synthetic EDU flow record.

Secondly, collect average daily flow data for gages with a variety of drainage areas for a period of time to cover the pollutant record. From these flow records normalize the flow to a per square mile basis. Average the log transformations of the average daily discharge for each day in the period of record. For each gage record used to build this synthetic flow record calculate the Nash-Sutcliffe statistic to determine if the relationship is valid for each record. This relationship must be valid in order to use this methodology. This new synthetic record of flow per square mile is used to develop the load duration for the EDU. The flow record should be of sufficient length to be able to calculate percentiles of flow.

¹⁰ Lotic = pertaining to moving water

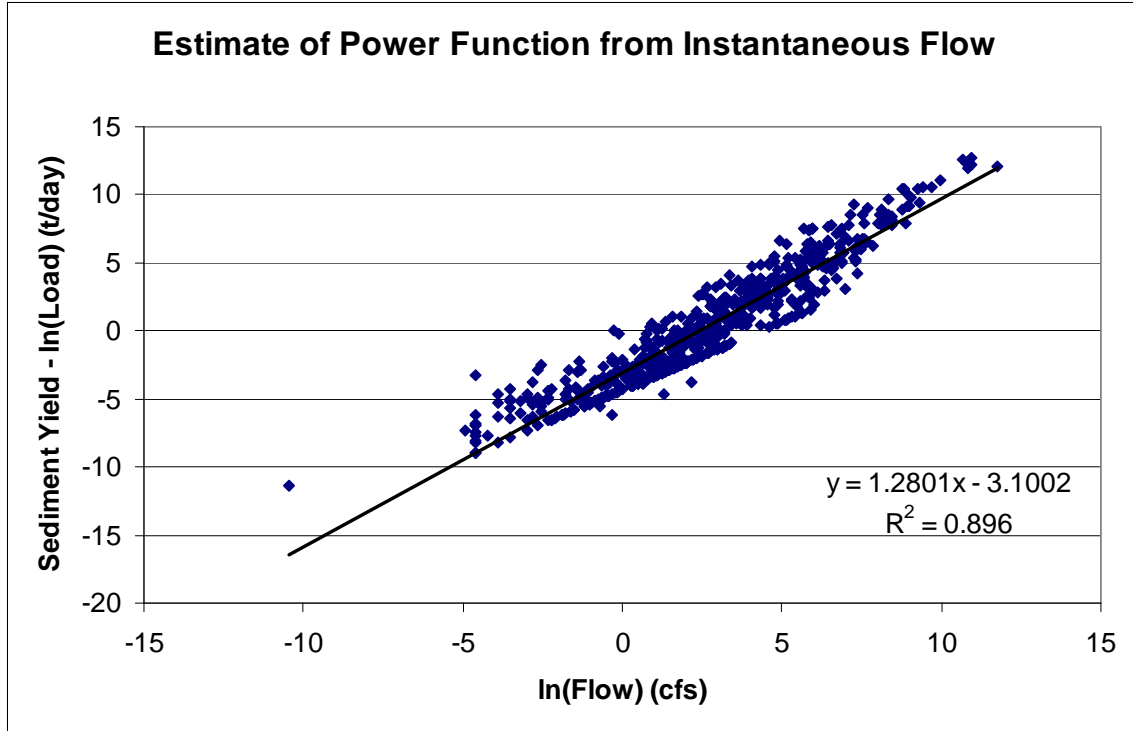
The following shows the application of the approach for the Plains\Grand\Chariton EDU in which Hickory Creek is located. The watershed-size normalized data for the individual gages in the EDU were calculated and compared to a pooled data set including all of the gages. The results of this analysis are displayed in the following figure and table:



| Gage Name | Gage ID | Area (mi ²) | Nash-Sutcliffe |
|---------------------|----------|-------------------------|----------------|
| East Fork Big Creek | 06897000 | 95 | 95% |
| Thompson River | 06899500 | 1720 | 100% |
| Medicine Creek | 06900050 | 355 | 90% |
| Locust Creek | 06901500 | 550 | 97% |

The Nash-Sutcliffe model efficiency statistics demonstrates the pooled data set can confidently be used as a surrogate for the EDU analyses.

The next step is to calculate pollutant-discharge relationships for the EDU, these are log transformed data for the yield (tons/mi²/day) and the instantaneous flow (cfs/mi².) The following graph shows the EDU relationship:



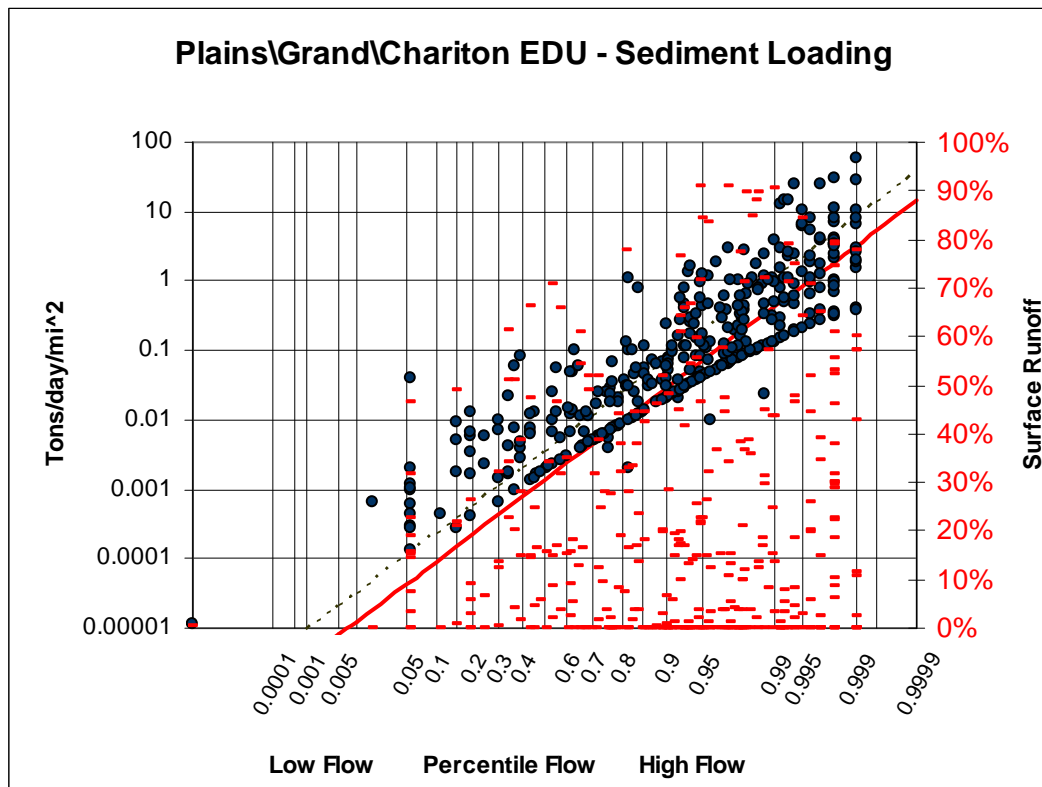
Further statistical analyses on this relationship are included in the following table:

| | | | |
|--------------------|------------|--------------------|--------------|
| m | 1.28005971 | b | -3.100187544 |
| Standard Error (m) | 0.01732333 | Standard Error (b) | 0.071372109 |
| r ² | 0.89596436 | Standard Error (y) | 1.407435901 |
| F | 5460.06529 | DF | 634 |
| SSreg | 10815.7113 | SSres | 1255.875267 |

The standard error of y was used to estimate the 25 percentile level for the TMDL line. This was done by adjusting the intercept (b) by subtracting the product of the one-sided Z₇₅ statistic times the standard error of (y). The resulting TMDL Equation is the following:

$$\text{Sediment yield (t/day/mi}^2\text{)} = \exp (1.28005971 * \ln (\text{flow}) - 4.05021)$$

A resulting pooled TMDL of all data in the Plains\Grand\Chariton EDU is shown in the following graph:



The above process was applied to the Hickory Creek watershed using individual watershed data compared to the above TMDL curve that has been multiplied by the watershed area. Data from the impaired segment is then plotted as a load (tons/day) for the y-axis and as the percentile of flow for the EDU on the day the sample was taken for the x-axis.

For more information contact:
Environmental Protection Agency, Region 7
Water, Wetlands, and Pesticides Division
Total Maximum Daily Load Program
901 North 5th Street
Kansas City, Kansas 66101
Website: <http://www.epa.gov/region07/water/tmdl.htm>

Appendix C

Development of Nutrient Targets using EPA Recommended Ecoregion Nutrient Criteria with Load Duration Curves

Overview

This procedure is used when a lotic system is placed on the 303(d) impaired water body list for nutrient pollution and the designated use being addressed is aquatic life. In cases where U.S. Environmental Protection Agency (EPA) approved state numeric criteria for the impaired stream is not available, a reference approach is used. The target for pollutant loading is the EPA recommended ecoregion nutrient criterion for the specific ecoregion in which the water body is located (USEPA, 2000). If a flow record for the impaired stream is not available a synthetic flow record is needed. To develop a synthetic flow record a user should calculate an average of the log discharge per square mile of U.S. Geological Survey (USGS) gaged rivers for which the drainage area is contained within the ecological drainage unit (EDU) (Table C.1). From this synthetic record develop a flow duration and build a load duration curve (LDC) for the pollutant within the EDU.

See USEPA (2000) for more detailed information as to how recommended ecoregion nutrient criteria were developed. This appendix describes how the nutrient criteria (TN and TP) are expressed in this TMDL.

Methodology

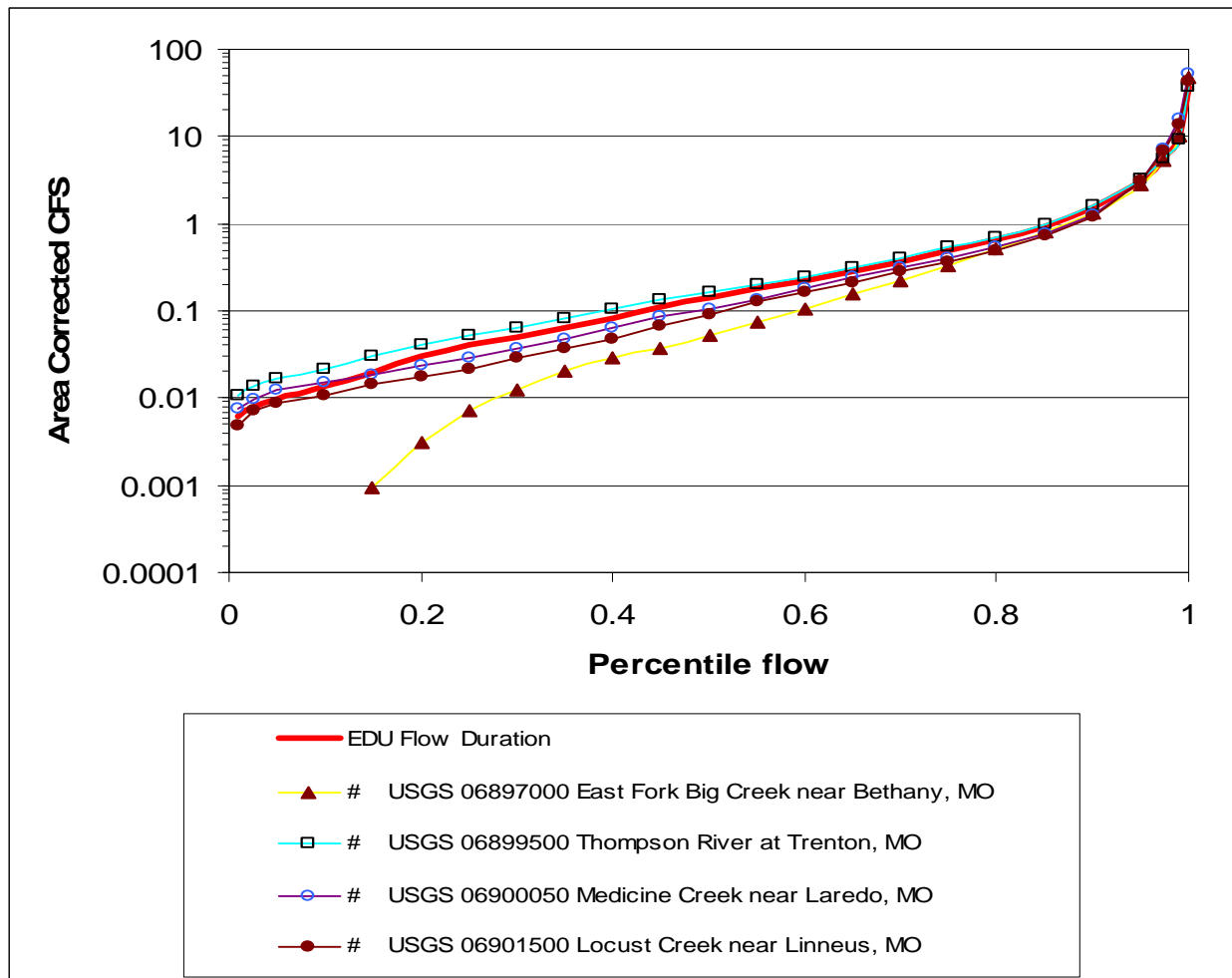
The first step in this procedure is to gather available nutrient data within the ecoregion of interest (Tables C.2. and C.3). These data, along with the instantaneous flow measurement taken at the time of sample collection for the specific date, are required to develop the LDC. Both dates and nutrient concentrations are needed in order to match the measured data used with the synthetic EDU flow record.

Secondly, collect average daily flow data from gages with a variety of drainage areas for a period of time to cover the nutrient record. From these flow records normalize the flow to a per square mile basis. Average the log transformations of the average daily discharge for each day in the period of record. For each gage record used to build the synthetic flow record calculate the Nash-Sutcliffe value to determine if the relationship is valid for each record. This relationship must be valid in order to use this methodology. This new synthetic record of flow per square mile is then used to develop the LDC for the EDU. The flow record should be of sufficient length to be able to calculate percentiles of flow (typically 20 years or more). Figure C.1. presents a graph of the synthetic normalized flow duration curve and normalized flow duration curves for the four USGS gages (Table C.1.) used in the analysis.

Table C.1. U.S. Geological Survey Gages used to develop synthetic flow regime for Plains\Grand\Chariton EDU

| Gage Number | Gage Name | Drainage Area (mi ²) | Time Periods Used |
|---------------|--------------------------------------|----------------------------------|-------------------------|
| USGS 06897000 | East Fork Big Creek near Bethany, MO | 95 | 10/01/1996 - 09/30/2009 |
| USGS 06899500 | Thompson River at Trenton, MO | 1720 | 10/01/1989- 09/30/2009 |
| USGS 06900050 | Medicine Creek near Laredo, MO | 355 | 11/14/2000 - 09/30/2009 |
| USGS 06901500 | Locust Creek near Linneus, MO | 550 | 07/14/2000 - 09/30/2009 |

Figure C.1. Synthetic Flow Duration Curve, Plains\Grand\Chariton EDU



The next step was to collect previously measured water quality data from within the ecoregion. In the following example, measured TN concentrations are adjusted so their median is equal to the EPA recommended ecoregion TN criterion. This is accomplished by subtracting the difference between the EPA recommended ecoregion TN criterion and the median from the measured data. This results in the data retaining most of its natural variability yet having a median which meets the EPA recommended ecoregion TN criterion. Where this adjustment would result in a negative concentration the minimum measured concentration is substituted.

Figures C.2. and C.3. show examples of this process where the solid line is the measured distribution of the natural log TN and TP concentration with the natural log flow and the dashed line represents a data distribution (the adjusted data) which would comply with the EPA recommended ecoregion TN and TP criteria.

Figure C.2. Graphic Representation of Data Adjustment for TN

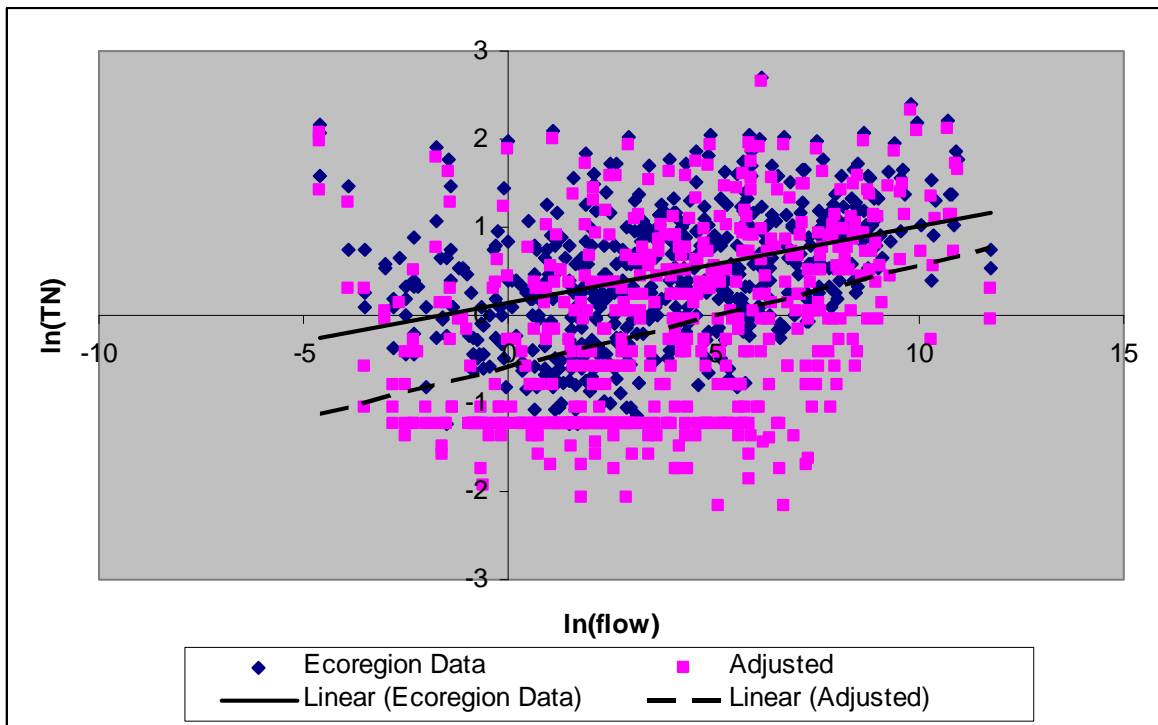
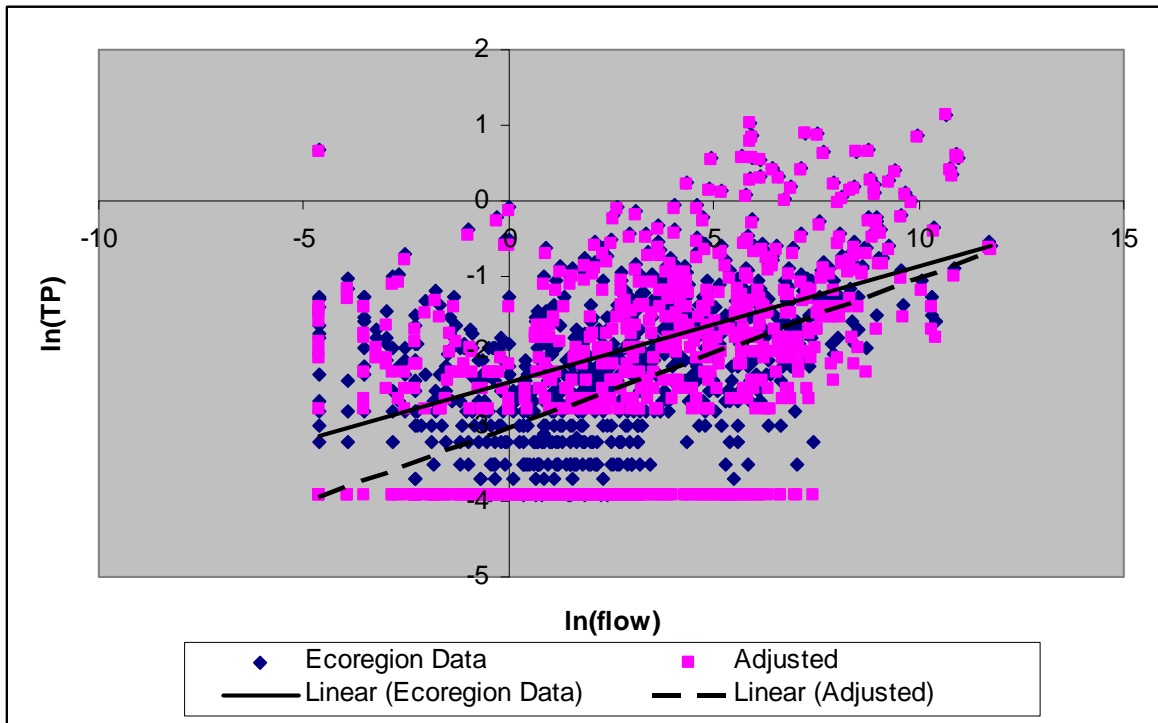


Figure C.3. Graphic Representation of Data Adjustment for TP



The next step was to calculate the TN and TP – discharge relationships for the ecoregion using the adjusted data, this is natural log transformed data for the yield (pounds/mi²/day) and the instantaneous flow (cfs/mi²). Figures C.4. and C.5. show these relationships for the Hickory Creek TMDL.

Figure C.4. Load / Flow Relationship Used to Set TN Load Duration Curve

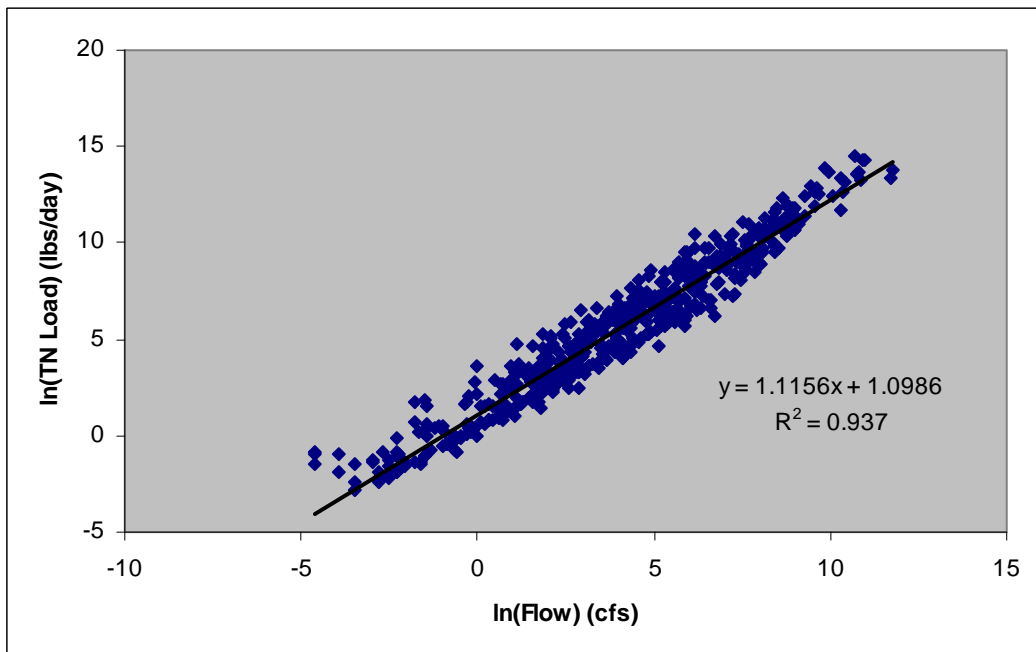
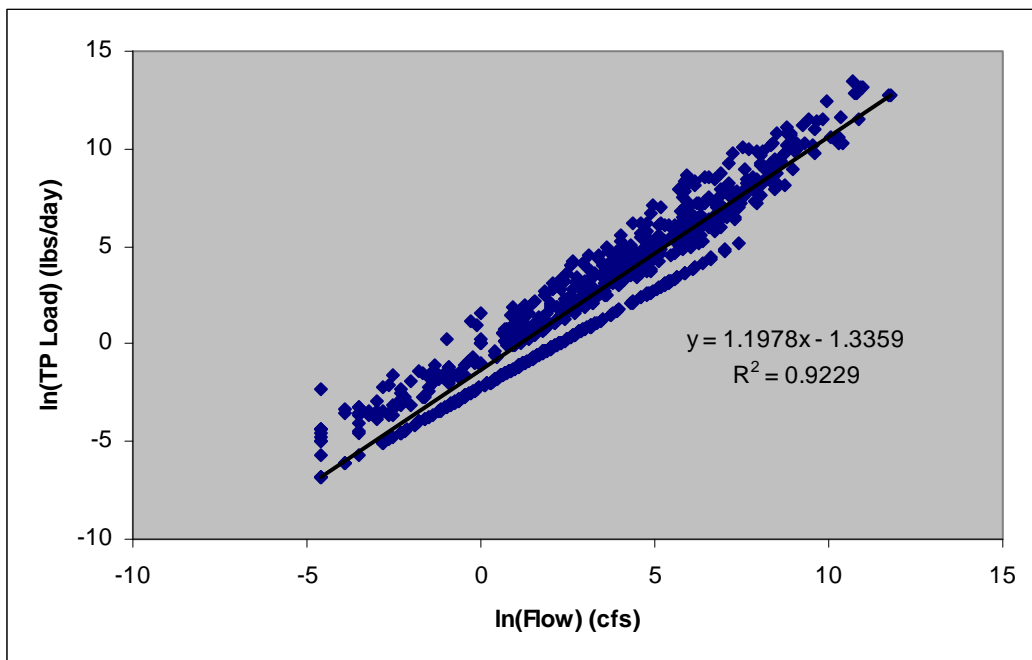


Figure C.5. Load / Flow Relationship Used to Set TP Load Duration Curve



This relationship was used to develop a LDC for which the relationship between flow and nutrient distribution is taken into account. In this LDC the targeted concentration is allowed to change at different percentiles of flow exceedance. However, meeting the LDC will result in a water body in which the median concentration is equal to the EPA recommended ecoregion criterion.

To apply this process to a specific watershed entails using the individual watershed data compared to the TMDL curve that has been multiplied by the watershed area (mi^2). Data from the impaired segment is then plotted as a load (pounds/day) for the y-axis and as the percentile of flow for the EDU on the day the sample was taken for the x-axis. These data points do not have to be collected at the segment outlet. The spreadsheet applies an outlet flow (percentile exceedance) to the concentration based on the synthetic flow estimate for the specific date the sample was taken.

The resulting LDC with plotted site specific measured data can now be used to target implementation by identifying flows in which TN concentrations are higher than would be expected in a stream meeting the EPA recommended ecoregion TN criterion. See LDCs in TMDL, Figures 4 and 5.

Table C.2. Sites for water quality data (This information, except for drainage area, is in the following table).

| Gage# | Name | Drainage Area |
|---------|---------------------------------------|---------------|
| 6898100 | Thompson River at Mount Moriah, MO | 891 |
| 6898800 | Weldon River near Princeton, MO | 452 |
| 6899580 | No Creek near Dunlap, MO | 34 |
| 6899585 | No Creek at Farmersville, MO (n=1) | 67.4 |
| 6899950 | Medicine Creek near Harris, MO | 192 |
| 6900100 | Little Medicine Creek near Harris, MO | 66.5 |
| 6901500 | Locust Creek near Linneus, MO | 550 |
| 6902000 | Grand River near Summner, MO | 6880 |
| 6905725 | Mussel Fork near Mystic, MO | 24 |

Table C.3. Data used to develop TSS targets and to develop distribution for nutrient targets

Data collected by USGS and provided by EPA

(Where data are estimated (E) the estimate was used. Where data was less than the limit of detection [$<$] a value one half the limit of detection was used.)

| USGS Gage Number | Sample Date | Flow (cfs) | TSS (mg/L) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|---|-------------|------------|------------|-----------------------|-------------------------|
| Thompson River at Mount Moriah, MO | | | | | |
| 6898100 | 11/9/1999 | 22 | 527 | | 0.86 |
| 6898100 | 1/13/2000 | 8.6 | | 0.7 | E 0.04 |
| 6898100 | 3/23/2000 | 33 | | | 0.26 |
| 6898100 | 5/18/2000 | 19 | 27 | | 0.14 |
| 6898100 | 7/13/2000 | 49 | | | 0.2 |
| 6898100 | 9/6/2000 | 10 | | | 0.53 |
| 6898100 | 11/28/2000 | 15 | < 10 | 0.77 | E 0.03 |
| 6898100 | 1/3/2001 | 7.5 | | 0.75 | < 0.06 |
| 6898100 | 3/15/2001 | 4860 | | 5.6 | 1.92 |
| 6898100 | 5/2/2001 | 276 | 156 | 1.7 | 0.26 |
| 6898100 | 7/13/2001 | 126 | | | 0.16 |
| 6898100 | 9/20/2001 | 53 | | E 0.67 | 0.11 |
| 6898100 | 11/8/2001 | 41 | 14 | | E 0.06 |
| 6898100 | 1/17/2002 | 14 | < 10 | 0.74 | E 0.03 |
| 6898100 | 3/14/2002 | 91 | 43 | 1.9 | 0.1 |
| 6898100 | 5/9/2002 | 223 | 347 | 1.8 | 0.39 |
| 6898100 | 8/1/2002 | 26 | 30 | | 0.12 |
| 6898100 | 9/3/2002 | 17 | 176 | | 0.3 |
| 6898100 | 11/7/2002 | 18 | < 10 | | 0.05 |
| 6898100 | 1/15/2003 | 15 | < 10 | | E 0.04 |
| 6898100 | 3/28/2003 | 50 | 11 | 0.68 | 0.07 |
| 6898100 | 5/22/2003 | 196 | 107 | 5.1 | 0.22 |
| 6898100 | 7/15/2003 | 76 | 66 | 1.4 | 0.28 |

| USGS Gage Number | Sample Date | Flow (cfs) | TSS (mg/L) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|--|-------------|---------------|---------------|--------------------------|----------------------------|
| 6898100 | 8/29/2003 | 6.1 | < 10 | | 0.08 |
| 6898100 | 9/4/2003 | 10 | 146 | | 0.34 |
| 6898100 | 11/4/2003 | 325 | 644 | 4 | 1.08 |
| 6898100 | 1/23/2004 | 23 | < 10 | 0.82 | E 0.04 |
| 6898100 | 3/25/2004 | 268 | 186 | 5 | 0.3 |
| 6898100 | 5/20/2004 | E 837 | 593 | 7.6 | 1.03 |
| 6898100 | 7/9/2004 | 118 | 17 | 2.8 | 0.28 |
| 6898100 | 9/10/2004 | 259 | 82 | 1.2 | 0.26 |
| 6898100 | 11/8/2004 | 70 | 132 | | 0.24 |
| 6898100 | 1/21/2005 | 31 | < 10 | 0.95 | E 0.03 |
| 6898100 | 3/3/2005 | 144 | 42 | 2.4 | 0.09 |
| 6898100 | 5/25/2005 | 342 | 292 | 3.8 | 0.39 |
| 6898100 | 7/8/2005 | 96 | 67 | | 0.19 |
| 6898100 | 9/16/2005 | 23 | < 10 | E 0.32 | 0.05 |
| 6898100 | 11/10/2005 | 12 | < 10 | | 0.04 |
| 6898100 | 1/20/2006 | 23 | < 10 | | 0.04 |
| 6898100 | 3/31/2006 | 23 | < 10 | | 0.04 |
| 6898100 | 5/25/2006 | 81 | 100 | | 0.22 |
| 6898100 | 7/27/2006 | 15 | 23 | | 0.1 |
| 6898100 | 9/8/2006 | 44 | 28 | | 0.13 |
| 6898100 | 11/9/2006 | 23 | < 10 | | 0.05 |
| 6898100 | 1/4/2007 | 381 | 333 | 7.4 | 0.77 |
| 6898100 | 2/14/2007 | 24 | < 10 | 3.9 | E 0.03 |
| 6898100 | 3/21/2007 | 291 | 218 | 3.4 | 0.32 |
| 6898100 | 4/6/2007 | 394 | 192 | 3.2 | 0.3 |
| 6898100 | 5/23/2007 | 298 | 63 | 3.3 | 0.17 |
| 6898100 | 6/20/2007 | 133 | 82 | 2.1 | 0.18 |
| 6898100 | 7/25/2007 | 54 | 17 | | 0.09 |
| 6898100 | 9/19/2007 | 132 | 26 | E 0.83 | 0.1 |
| 6898100 | 11/16/2007 | 137 | 48 | 2.1 | 0.14 |
| 6898100 | 1/24/2008 | 200 | 20 | 2.4 | 0.07 |
| 6898100 | 3/12/2008 | 682 | 328 | 2.9 | 0.55 |
| 6898100 | 5/29/2008 | 481 | 196 | 3.4 | 0.29 |
| 6898100 | 7/10/2008 | 1280 | 1440 | 5.2 | 1.52 |
| 6898100 | 9/17/2008 | 569 | 300 | 1.7 | 0.43 |
| 6898100 | 10/22/2008 | 1380 | 2930 | 5.2 | 2.44 |
| 6898100 | 1/14/2009 | 235 | 74 | 1.7 | 0.09 |
| 6898100 | 3/5/2009 | 264 | 254 | 2.2 | 0.35 |
| 6898100 | 5/7/2009 | 614 | 336 | 3.1 | 0.45 |
| 6898100 | 7/16/2009 | 1220 | 718 | 3.2 | 0.64 |
| 6898100 | 9/3/2009 | 288 | 109 | 1.2 | 0.25 |
| Weldon River near Princeton, MO | | | | | |
| 6898800 | 11/9/1999 | 5.3 | | 0.29 | 0.043 |
| 6898800 | 1/11/2000 | 10 | | 0.38 | < 0.05 |
| 6898800 | 3/21/2000 | 13 | | | E 0.03 |
| 6898800 | 5/16/2000 | 2.4 | < 10 | | < 0.05 |
| 6898800 | 7/11/2000 | 9.4 | | | 0.09 |

| USGS Gage Number | Sample Date | Flow (cfs) | TSS (mg/L) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|-----------------------------|--------------------|-----------------------|-----------------------|----------------------------------|------------------------------------|
| 6898800 | 9/6/2000 | 1.8 | | | 0.07 |
| 6898800 | 11/30/2000 | 5.2 | < 10 | 0.6 | < 0.060 |
| 6898800 | 1/5/2001 | 8.1 | | 0.54 | < 0.06 |
| 6898800 | 3/15/2001 | 2840 | | 3.9 | 1.28 |
| 6898800 | 5/2/2001 | 152 | 119 | 2.5 | 0.24 |
| 6898800 | 7/11/2001 | 63 | | | 0.13 |
| 6898800 | 9/18/2001 | 18 | | E 0.35 | < 0.06 |
| 6898800 | 11/6/2001 | 36 | 18 | 0.6 | 0.1 |
| 6898800 | 1/15/2002 | 20 | < 10 | 0.57 | < 0.06 |
| 6898800 | 3/12/2002 | 101 | 114 | 2.6 | 0.21 |
| 6898800 | 5/7/2002 | 527 | 210 | 2.3 | 0.5 |
| 6898800 | 7/30/2002 | 17 | 14 | | 0.07 |
| 6898800 | 8/15/2002 | 8.7 | 20 | | 0.07 |
| 6898800 | 9/5/2002 | 3.3 | 13 | | E 0.04 |
| 6898800 | 10/24/2002 | 5 | < 10 | E 0.34 | E 0.03 |
| 6898800 | 11/5/2002 | 6.5 | < 10 | | < 0.04 |
| 6898800 | 12/10/2002 | 4.3 | < 10 | E 0.29 | E 0.02 |
| 6898800 | 1/14/2003 | 1.9 | < 10 | | E 0.02 |
| 6898800 | 3/7/2003 | 8.6 | < 10 | 0.64 | E 0.03 |
| 6898800 | 3/26/2003 | 7.3 | < 10 | | 0.04 |
| 6898800 | 5/20/2003 | 168 | 264 | 1.7 | 0.33 |
| 6898800 | 7/17/2003 | 6.1 | 19 | | 0.08 |
| 6898800 | 9/5/2003 | 0.73 | 52 | | < 0.04 |
| 6898800 | 11/6/2003 | 99 | 120 | 4.5 | 0.5 |
| 6898800 | 1/21/2004 | 30 | 19 | 2.5 | 0.13 |
| 6898800 | 3/23/2004 | 90 | 39 | 1.7 | 0.12 |
| 6898800 | 5/18/2004 | 473 | 267 | 15 | 1.73 |
| 6898800 | 7/7/2004 | 44 | 14 | | 0.08 |
| 6898800 | 9/8/2004 | 166 | 85 | 0.86 | 0.2 |
| 6898800 | 11/10/2004 | 20 | < 10 | E 0.35 | E 0.03 |
| 6898800 | 1/19/2005 | 11 | < 10 | 0.59 | < 0.04 |
| 6898800 | 3/1/2005 | 80 | 51 | 1.1 | 0.07 |
| 6898800 | 5/23/2005 | 128 | 266 | 2.2 | 0.34 |
| 6898800 | 7/6/2005 | 23 | < 10 | | E 0.04 |
| 6898800 | 9/14/2005 | 6 | 10 | | 0.05 |
| 6898800 | 11/8/2005 | 6.5 | 21 | | 0.04 |
| 6898800 | 1/18/2006 | 9.4 | < 10 | | < 0.04 |
| 6898800 | 3/31/2006 | 117 | 750 | 3 | 0.8 |
| 6898800 | 5/23/2006 | 6.1 | 12 | | 0.04 |
| 6898800 | 7/25/2006 | 1.5 | 60 | | 0.11 |
| 6898800 | 9/6/2006 | 9.2 | 42 | | 0.08 |
| 6898800 | 11/7/2006 | 5.5 | < 10 | | 0.06 |
| 6898800 | 1/4/2007 | 82 | 44 | 3.7 | 0.23 |
| 6898800 | 2/16/2007 | 7.2 | < 10 | 0.42 | E 0.03 |
| 6898800 | 3/23/2007 | 625 | 1250 | 5.5 | 1.52 |
| 6898800 | 4/6/2007 | 174 | 86 | 1.4 | 0.15 |
| 6898800 | 5/23/2007 | 97 | 28 | 1 | 0.09 |

| USGS Gage Number | Sample Date | Flow (cfs) | TSS (mg/L) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|-----------------------------|-------------|---------------|---------------|--------------------------|----------------------------|
| 6898800 | 6/20/2007 | 35 | 31 | | 0.12 |
| 6898800 | 7/25/2007 | 19 | 15 | | 0.07 |
| 6898800 | 9/19/2007 | 42 | 24 | | 0.07 |
| 6898800 | 11/14/2007 | 24 | 13 | E 0.46 | 0.06 |
| 6898800 | 1/24/2008 | 60 | 140 | 1.6 | 0.26 |
| 6898800 | 3/12/2008 | 615 | 472 | 1.9 | 0.48 |
| 6898800 | 5/29/2008 | 166 | 79 | 1.2 | 0.17 |
| 6898800 | 7/10/2008 | 307 | 426 | 2.8 | 0.6 |
| 6898800 | 9/17/2008 | 325 | 364 | 1.4 | 0.41 |
| 6898800 | 10/22/2008 | 6480 | 1850 | 4.9 | 1.93 |
| 6898800 | 1/14/2009 | 78 | < 15 | 0.92 | E 0.04 |
| 6898800 | 3/6/2009 | 121 | 112 | 0.76 | 0.14 |
| 6898800 | 5/7/2009 | 260 | 126 | 1.2 | 0.21 |
| 6898800 | 7/16/2009 | 98 | 54 | | 0.16 |
| 6898800 | 9/3/2009 | 274 | 145 | 1.1 | 0.26 |
| No Creek near Dunlap | | | | | |
| 6899580 | 1/22/1998 | 3.7 | 1 | | |
| 6899580 | 6/2/1998 | 3.2 | 51 | | |
| 6899580 | 3/30/1999 | 4.4 | | 0.48 | E 0.05 |
| 6899580 | 4/22/1999 | 14 | | 0.77 | 0.13 |
| 6899580 | 6/21/1999 | 0.25 | 70 | | 0.14 |
| 6899580 | 10/25/1999 | 0.01 | | 8.6 | 0.19 |
| 6899580 | 11/29/1999 | 0.01 | 73 | | 0.24 |
| 6899580 | 12/20/1999 | 0.1 | | | 0.09 |
| 6899580 | 1/24/2000 | 0.1 | 28 | 1.4 | 0.12 |
| 6899580 | 2/23/2000 | 0.06 | | | 0.14 |
| 6899580 | 4/20/2000 | 0.81 | | | 0.16 |
| 6899580 | 5/9/2000 | 0.17 | 54 | 6.7 | 0.3 |
| 6899580 | 6/14/2000 | 6.4 | | 6.3 | 0.46 |
| 6899580 | 6/22/2000 | 0.4 | | 1.3 | 0.18 |
| 6899580 | 7/25/2000 | 0.11 | 45 | 1.4 | 0.15 |
| 6899580 | 10/24/2000 | 0.37 | | 1.6 | 0.67 |
| 6899580 | 11/15/2000 | 0.68 | 21 | 2.1 | 0.14 |
| 6899580 | 12/19/2000 | 0.08 | | E 1.4 | E 0.06 |
| 6899580 | 1/24/2001 | 1.6 | 18 | 2.9 | 0.1 |
| 6899580 | 2/15/2001 | 40 | | 2.8 | 0.34 |
| 6899580 | 3/27/2001 | 10 | | 1.6 | 0.12 |
| 6899580 | 4/24/2001 | 19 | | 1.3 | 0.18 |
| 6899580 | 5/22/2001 | 9.9 | 41 | 1.3 | 0.15 |
| 6899580 | 6/19/2001 | 2.7 | | 1.6 | 0.23 |
| 6899580 | 6/25/2001 | 5.2 | | 1.1 | 0.18 |
| 6899580 | 7/26/2001 | 59 | 290 | 1.7 | 0.35 |
| 6899580 | 8/9/2001 | 0.47 | | E 0.75 | 0.12 |
| 6899580 | 9/13/2001 | 0.1 | | E 2.4 | 0.15 |
| 6899580 | 10/23/2001 | 38 | 386 | 2.3 | 0.72 |
| 6899580 | 11/29/2001 | 0.28 | 78 | | 0.19 |
| 6899580 | 12/13/2001 | 1 | 20 | | 0.1 |

| USGS Gage Number | Sample Date | Flow (cfs) | TSS (mg/L) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|-----------------------------|--------------------|-----------------------|-----------------------|----------------------------------|------------------------------------|
| 6899580 | 2/28/2002 | 1.7 | 22 | 1.2 | 0.07 |
| 6899580 | 3/21/2002 | 2.1 | < 10 | | E 0.03 |
| 6899580 | 4/18/2002 | 4.3 | 36 | 0.75 | 0.12 |
| 6899580 | 5/23/2002 | 2.4 | < 10 | E 0.51 | 0.07 |
| 6899580 | 6/13/2002 | 0.53 | 20 | 0.64 | 0.1 |
| 6899580 | 6/28/2002 | 0.07 | 40 | | 0.11 |
| 6899580 | 7/23/2002 | 0.01 | < 10 | E 8.0 | 0.17 |
| 6899580 | 8/22/2002 | 1 | 44 | 7.3 | 0.91 |
| 6899580 | 12/19/2002 | 0.01 | 37 | | 0.16 |
| 6899580 | 3/13/2003 | 0.41 | < 10 | | 0.17 |
| 6899580 | 3/20/2003 | 0.34 | 12 | | 0.15 |
| 6899580 | 4/25/2003 | 2.1 | 82 | 1.2 | 0.22 |
| 6899580 | 4/30/2003 | 0.62 | 12 | | 0.14 |
| 6899580 | 5/6/2003 | 6.4 | 164 | 3.5 | 0.38 |
| 6899580 | 6/12/2003 | 3 | 68 | 8.2 | 0.24 |
| 6899580 | 7/9/2003 | 0.01 | 43 | 4.9 | 0.27 |
| 6899580 | 9/19/2003 | 0.26 | 144 | 1.1 | 0.28 |
| 6899580 | 10/23/2003 | 0.03 | 70 | | 0.28 |
| 6899580 | 11/18/2003 | 0.1 | 23 | | 0.22 |
| 6899580 | 12/11/2003 | 22 | 120 | 3.7 | 0.43 |
| 6899580 | 1/8/2004 | 1 | 17 | 2.3 | 0.11 |
| 6899580 | 2/27/2004 | 5.8 | 14 | 1.9 | 0.11 |
| 6899580 | 3/18/2004 | 52 | 117 | 2 | 0.25 |
| 6899580 | 4/20/2004 | 2.7 | 33 | | 0.1 |
| 6899580 | 5/11/2004 | 1.3 | < 10 | | 0.08 |
| 6899580 | 6/22/2004 | 9.1 | 49 | 1.1 | 0.17 |
| 6899580 | 7/16/2004 | 0.41 | 23 | E 0.78 | 0.14 |
| 6899580 | 8/23/2004 | 0.72 | 67 | E 0.77 | 0.14 |
| 6899580 | 9/14/2004 | 0.76 | 520 | E 2.6 | 0.79 |
| 6899580 | 10/26/2004 | 1 | < 10 | | 0.28 |
| 6899580 | 11/16/2004 | 3.7 | < 10 | 0.46 | 0.06 |
| 6899580 | 12/14/2004 | 6.2 | 18 | 0.65 | 0.08 |
| 6899580 | 1/25/2005 | 0.08 | 18 | 1.2 | 0.14 |
| 6899580 | 2/10/2005 | 21 | 138 | 1.4 | 0.16 |
| 6899580 | 3/17/2005 | 2.9 | < 10 | | E 0.04 |
| 6899580 | 4/5/2005 | 3.6 | < 10 | | 0.04 |
| 6899580 | 5/12/2005 | 2 | 52 | | 0.14 |
| 6899580 | 6/30/2005 | 0.86 | 24 | 0.73 | 0.12 |
| 6899580 | 7/13/2005 | 0.03 | < 10 | | 0.06 |
| 6899580 | 8/19/2005 | 0.02 | 33 | | 0.09 |
| 6899580 | 9/21/2005 | 0.05 | 53 | | 0.12 |
| 6899580 | 10/5/2005 | 0.08 | 380 | | 0.49 |
| 6899580 | 11/3/2005 | 0.01 | 1510 | | 1.94 |
| 6899580 | 12/14/2005 | 0.1 | 44 | E 1.5 | 0.19 |
| 6899580 | 1/25/2006 | 0.03 | 43 | | 0.11 |
| 6899580 | 2/14/2006 | 0.01 | 22 | | 0.1 |
| 6899580 | 3/9/2006 | 0.2 | < 10 | | 0.07 |

| USGS Gage Number | Sample Date | Flow (cfs) | TSS (mg/L) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|---------------------------------------|--------------------|-----------------------|-----------------------|----------------------------------|------------------------------------|
| 6899580 | 4/12/2006 | 2.1 | 72 | 0.95 | 0.16 |
| 6899580 | 5/9/2006 | 2.8 | 44 | 0.93 | 0.13 |
| 6899580 | 6/15/2006 | 0.23 | 24 | 5.8 | 0.13 |
| 6899580 | 7/19/2006 | 0 | 152 | | 0.59 |
| 6899580 | 8/10/2006 | 3.1 | 147 | 1.6 | 0.34 |
| 6899580 | 9/21/2006 | 0.02 | 170 | E 4.3 | 0.31 |
| 6899580 | 10/25/2006 | 0.02 | 93 | E 2.1 | 0.35 |
| 6899580 | 12/13/2006 | 0.52 | 17 | 0.92 | 0.12 |
| 6899580 | 1/26/2007 | 0.84 | < 10 | 1 | E 0.04 |
| 6899580 | 2/20/2007 | 56 | 162 | 3.8 | 0.68 |
| 6899580 | 3/15/2007 | 8.1 | 37 | 1.2 | 0.09 |
| 6899580 | 4/27/2007 | 76 | 225 | 2.9 | 0.38 |
| 6899580 | 5/10/2007 | 18 | 110 | 2.7 | 0.23 |
| 6899580 | 6/28/2007 | 19 | 485 | 7.6 | 0.64 |
| 6899580 | 7/19/2007 | E 0.03 | 165 | E 1.3 | 0.21 |
| 6899580 | 8/23/2007 | 0.24 | 75 | 1.5 | 0.21 |
| 6899580 | 9/27/2007 | 0.19 | 105 | | 0.25 |
| 6899580 | 10/16/2007 | 0.06 | 136 | E 1.2 | 0.36 |
| 6899580 | 11/8/2007 | 0.01 | 16 | | 0.28 |
| 6899580 | 12/20/2007 | 3.1 | 20 | 2.2 | 0.14 |
| 6899580 | 1/10/2008 | 22 | 58 | 2 | 0.23 |
| 6899580 | 2/26/2008 | E 65 | 86 | 2.9 | 0.35 |
| 6899580 | 3/25/2008 | 8.3 | 34 | 0.95 | 0.1 |
| 6899580 | 4/16/2008 | 11 | 102 | 1.2 | 0.18 |
| 6899580 | 5/22/2008 | 2.1 | 138 | E 1.0 | 0.22 |
| 6899580 | 6/17/2008 | 13 | 74 | 1.3 | 0.22 |
| 6899580 | 7/15/2008 | 0.8 | 46 | 1.1 | 0.14 |
| 6899580 | 8/12/2008 | 0.55 | 24 | E 0.54 | 0.1 |
| 6899580 | 9/23/2008 | 3 | < 10 | 0.44 | 0.09 |
| 6899580 | 10/28/2008 | 6.6 | < 15 | 0.65 | 0.13 |
| 6899580 | 11/18/2008 | 11 | < 15 | 0.65 | 0.1 |
| 6899580 | 12/2/2008 | 5.8 | < 15 | 0.54 | 0.07 |
| 6899580 | 1/27/2009 | 1.9 | < 15 | E 0.34 | E 0.04 |
| 6899580 | 2/24/2009 | 3 | 16 | | 0.05 |
| 6899580 | 3/12/2009 | 16 | 250 | 2.1 | 0.34 |
| 6899580 | 4/24/2009 | 6.5 | 16 | E 0.48 | 0.08 |
| 6899580 | 5/15/2009 | 29 | 730 | 2.7 | 0.65 |
| 6899580 | 6/23/2009 | 20 | < 150 | 1.8 | 0.27 |
| 6899580 | 8/18/2009 | 56 | 266 | 2 | 0.38 |
| No Creek at Farmersville, MO | | | | | |
| 6899585 | 11/16/2006 | 0.13 | < 10 | 0.44 | 0.26 |
| Medicine Creek near Harris, MO | | | | | |
| 6899950 | 10/26/1999 | 2.3 | | | E 0.045 |
| 6899950 | 11/30/1999 | 3 | 6 | | < 0.05 |
| 6899950 | 12/21/1999 | 0.1 | | 0.65 | < 0.05 |
| 6899950 | 1/25/2000 | 0.5 | 3 | | < 0.05 |
| 6899950 | 2/22/2000 | 15 | | | E 0.04 |

| USGS Gage Number | Sample Date | Flow (cfs) | TSS (mg/L) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|-----------------------------|--------------------|-----------------------|-----------------------|----------------------------------|------------------------------------|
| 6899950 | 3/27/2000 | 8.7 | | | E 0.03 |
| 6899950 | 4/18/2000 | 4 | | | E 0.03 |
| 6899950 | 5/10/2000 | 10 | < 10 | | 0.05 |
| 6899950 | 6/21/2000 | 6 | | 0.87 | 0.08 |
| 6899950 | 7/26/2000 | 6.6 | 37 | | 0.11 |
| 6899950 | 9/20/2000 | 3.4 | | 0.54 | 0.07 |
| 6899950 | 10/26/2000 | 6.1 | | | 0.07 |
| 6899950 | 11/14/2000 | 5.8 | < 10 | 0.93 | 0.09 |
| 6899950 | 12/18/2000 | 3.1 | | E 0.34 | < 0.06 |
| 6899950 | 1/25/2001 | 12 | < 10 | 3.2 | 0.11 |
| 6899950 | 2/13/2001 | 131 | | 2.8 | 0.3 |
| 6899950 | 3/29/2001 | 100 | | 2 | 0.21 |
| 6899950 | 4/26/2001 | 76 | | 1 | 0.21 |
| 6899950 | 5/24/2001 | 52 | 68 | 1.3 | 0.18 |
| 6899950 | 6/19/2001 | 79 | | 1.5 | 0.33 |
| 6899950 | 6/26/2001 | 60 | | 1.1 | 0.18 |
| 6899950 | 7/25/2001 | 353 | 1610 | 3.2 | 1.34 |
| 6899950 | 8/8/2001 | 13 | | E 0.55 | 0.09 |
| 6899950 | 9/12/2001 | 7.4 | | 0.5 | 0.07 |
| 6899950 | 10/25/2001 | 33 | 118 | 2.6 | 0.37 |
| 6899950 | 11/28/2001 | 3.4 | 12 | E 0.35 | E 0.03 |
| 6899950 | 12/12/2001 | 6.2 | | | < 0.06 |
| 6899950 | 1/3/2002 | 4.6 | < 10 | 0.55 | < 0.06 |
| 6899950 | 1/8/2002 | 5 | < 10 | E 0.45 | < 0.06 |
| 6899950 | 2/27/2002 | 9.9 | 12 | 1.3 | 0.07 |
| 6899950 | 3/19/2002 | 18 | < 10 | | 0.06 |
| 6899950 | 4/17/2002 | 68 | 130 | 1.4 | 0.24 |
| 6899950 | 5/21/2002 | 38 | 38 | 1 | 0.1 |
| 6899950 | 6/28/2002 | 5.6 | 13 | | E 0.06 |
| 6899950 | 7/24/2002 | 3.6 | < 10 | | 0.08 |
| 6899950 | 8/21/2002 | 17 | 41 | | 0.14 |
| 6899950 | 9/10/2002 | 1.4 | < 10 | | E 0.05 |
| 6899950 | 10/17/2002 | 1.4 | < 10 | | E 0.03 |
| 6899950 | 11/19/2002 | 2 | < 10 | | E 0.03 |
| 6899950 | 12/18/2002 | 2.8 | < 10 | | 0.04 |
| 6899950 | 1/30/2003 | 0.9 | < 10 | | E 0.03 |
| 6899950 | 2/20/2003 | 3.4 | < 10 | | E 0.03 |
| 6899950 | 3/12/2003 | 3.9 | < 10 | | 0.1 |
| 6899950 | 4/23/2003 | 14 | 12 | | 0.25 |
| 6899950 | 5/8/2003 | 27 | 104 | 2.9 | 0.29 |
| 6899950 | 6/11/2003 | 51 | 282 | 5.8 | 0.47 |
| 6899950 | 7/10/2003 | 65 | 161 | 1.5 | 0.3 |
| 6899950 | 8/25/2003 | 0.61 | < 10 | | 0.06 |
| 6899950 | 9/17/2003 | 4.5 | 49 | 1.4 | 0.36 |
| 6899950 | 10/22/2003 | 1.3 | < 10 | | 0.05 |
| 6899950 | 11/20/2003 | 3 | < 10 | | 0.06 |
| 6899950 | 12/10/2003 | 368 | E 692 | 5.5 | 2.81 |

| USGS Gage Number | Sample Date | Flow (cfs) | TSS (mg/L) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|-----------------------------|--------------------|-----------------------|-----------------------|----------------------------------|------------------------------------|
| 6899950 | 1/7/2004 | 6.2 | < 10 | 1.7 | 0.06 |
| 6899950 | 2/26/2004 | 55 | 66 | 2.4 | 0.34 |
| 6899950 | 3/16/2004 | 71 | 53 | 1.7 | 0.22 |
| 6899950 | 4/22/2004 | 21 | 12 | | 0.06 |
| 6899950 | 5/13/2004 | 11 | < 10 | | 0.05 |
| 6899950 | 6/23/2004 | 42 | 49 | 1.2 | 0.18 |
| 6899950 | 7/14/2004 | 32 | 76 | 1.3 | 0.24 |
| 6899950 | 8/25/2004 | 378 | 1700 | 4.9 | 1.77 |
| 6899950 | 9/16/2004 | 25 | 15 | | 0.1 |
| 6899950 | 10/27/2004 | 50 | 131 | 1.5 | 0.31 |
| 6899950 | 11/18/2004 | 16 | < 10 | | 0.04 |
| 6899950 | 12/16/2004 | 26 | < 10 | 0.82 | 0.05 |
| 6899950 | 1/27/2005 | 169 | 280 | 2.3 | 0.53 |
| 6899950 | 2/9/2005 | 105 | 165 | 2.2 | 0.25 |
| 6899950 | 3/16/2005 | 28 | < 10 | | 0.06 |
| 6899950 | 4/8/2005 | 77 | 79 | | 0.21 |
| 6899950 | 5/11/2005 | 24 | 15 | | 0.08 |
| 6899950 | 6/29/2005 | 77 | 620 | 5.6 | 1.27 |
| 6899950 | 7/12/2005 | 5.7 | < 10 | | 0.05 |
| 6899950 | 8/17/2005 | 6.2 | < 10 | 0.71 | 0.06 |
| 6899950 | 9/20/2005 | 3.6 | 14 | E 0.37 | 0.05 |
| 6899950 | 10/5/2005 | 2.8 | 11 | | 0.04 |
| 6899950 | 11/2/2005 | 2 | < 10 | | E 0.03 |
| 6899950 | 12/15/2005 | 4.4 | < 10 | | E 0.02 |
| 6899950 | 1/26/2006 | 2.6 | < 10 | | E 0.03 |
| 6899950 | 2/17/2006 | 1.3 | < 10 | | 0.04 |
| 6899950 | 3/8/2006 | 9.8 | < 10 | | 0.06 |
| 6899950 | 4/13/2006 | 12 | 15 | | 0.08 |
| 6899950 | 5/10/2006 | 18 | 20 | 0.59 | 0.07 |
| 6899950 | 6/14/2006 | 2.4 | < 10 | | 0.04 |
| 6899950 | 7/18/2006 | 4.8 | 16 | | 0.13 |
| 6899950 | 8/9/2006 | 16 | 150 | 1.5 | 0.38 |
| 6899950 | 9/20/2006 | 1.4 | < 10 | | < 0.04 |
| 6899950 | 10/24/2006 | 3 | < 10 | | 0.08 |
| 6899950 | 11/15/2006 | 2.6 | < 10 | | 0.09 |
| 6899950 | 12/14/2006 | 4.4 | 24 | 1.5 | 0.07 |
| 6899950 | 1/25/2007 | 8 | < 10 | 1.3 | 0.06 |
| 6899950 | 2/21/2007 | 460 | 379 | 7.4 | 1.37 |
| 6899950 | 3/14/2007 | 60 | 72 | 2 | 0.2 |
| 6899950 | 4/27/2007 | 971 | 660 | 4.5 | 1.19 |
| 6899950 | 5/9/2007 | 349 | 424 | 2.8 | 0.63 |
| 6899950 | 6/27/2007 | 10 | 19 | 0.65 | 0.08 |
| 6899950 | 7/18/2007 | 4.6 | 10 | | 0.08 |
| 6899950 | 8/21/2007 | 57 | 763 | 3.2 | 0.93 |
| 6899950 | 9/25/2007 | 9.8 | < 20 | | 0.08 |
| 6899950 | 10/16/2007 | 46 | 84 | 1.2 | 0.25 |
| 6899950 | 11/6/2007 | 14 | < 10 | 0.49 | 0.09 |

| USGS Gage Number | Sample Date | Flow (cfs) | TSS (mg/L) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|--|-------------|---------------|---------------|--------------------------|----------------------------|
| 6899950 | 12/19/2007 | 57 | 35 | 1.7 | 0.13 |
| 6899950 | 1/9/2008 | 483 | 406 | 2.6 | 0.56 |
| 6899950 | 2/27/2008 | 202 | 140 | 3.5 | 0.45 |
| 6899950 | 3/26/2008 | 64 | 49 | 0.97 | 0.12 |
| 6899950 | 4/16/2008 | 119 | 170 | 1.5 | 0.27 |
| 6899950 | 5/21/2008 | 36 | 19 | | 0.1 |
| 6899950 | 6/18/2008 | 112 | 148 | 1.4 | 0.28 |
| 6899950 | 7/16/2008 | 19 | 35 | | 0.14 |
| 6899950 | 8/13/2008 | 25 | 46 | | 0.1 |
| 6899950 | 9/24/2008 | 98 | 536 | 2.6 | 0.61 |
| 6899950 | 10/29/2008 | 60 | 39 | 0.92 | 0.17 |
| 6899950 | 11/19/2008 | 75 | 42 | 0.83 | 0.12 |
| 6899950 | 12/3/2008 | 49 | 16 | 0.61 | 0.06 |
| 6899950 | 1/28/2009 | 19 | < 15 | 0.72 | 0.04 |
| 6899950 | 2/25/2009 | 34 | 22 | 0.61 | 0.06 |
| 6899950 | 3/11/2009 | 715 | 1180 | 4.9 | 1.37 |
| 6899950 | 4/22/2009 | 61 | 85 | 0.92 | 0.17 |
| 6899950 | 5/13/2009 | 377 | 1900 | 6.5 | 2.37 |
| 6899950 | 6/24/2009 | 75 | 220 | 2.4 | 0.42 |
| 6899950 | 7/22/2009 | 20 | 24 | | 0.1 |
| 6899950 | 8/20/2009 | 180 | 455 | 2.2 | 0.54 |
| Little Medicine Creek near Harris | | | | | |
| 6900100 | 1/22/1998 | 8.7 | 1 | | |
| 6900100 | 6/2/1998 | 11 | 26 | | |
| 6900100 | 1/5/1999 | 4.8 | 5 | 0.67 | < 0.05 |
| 6900100 | 3/31/1999 | 12 | | 0.37 | E 0.03 |
| 6900100 | 4/21/1999 | 35 | | 1.1 | 0.16 |
| 6900100 | 6/22/1999 | 4.7 | 30 | 0.97 | 0.11 |
| 6900100 | 8/25/1999 | 0.62 | | 0.56 | E 0.04 |
| 6900100 | 10/26/1999 | 0.67 | | | E 0.03 |
| 6900100 | 11/30/1999 | 0.73 | 1 | | < 0.05 |
| 6900100 | 12/21/1999 | 0.1 | | 0.82 | 0.06 |
| 6900100 | 1/25/2000 | 0.5 | 4 | | < 0.05 |
| 6900100 | 2/22/2000 | 1.8 | | | E 0.04 |
| 6900100 | 3/27/2000 | 1.1 | | | < 0.05 |
| 6900100 | 4/18/2000 | 2 | | | E 0.04 |
| 6900100 | 5/10/2000 | 1.4 | < 10 | | E 0.03 |
| 6900100 | 6/21/2000 | 1.2 | | 1.5 | 0.07 |
| 6900100 | 7/26/2000 | 1.6 | < 10 | | 0.07 |
| 6900100 | 9/20/2000 | 1.6 | | | 0.05 |
| 6900100 | 10/26/2000 | 1.8 | | | 0.08 |
| 6900100 | 11/14/2000 | 1.8 | < 10 | 1 | E 0.06 |
| 6900100 | 12/19/2000 | 0.91 | | 0.44 | E 0.04 |
| 6900100 | 1/25/2001 | 3.2 | < 10 | 3.2 | E 0.04 |
| 6900100 | 2/13/2001 | 46 | | 3.2 | 0.42 |
| 6900100 | 3/29/2001 | 35 | | 1.9 | 0.14 |
| 6900100 | 4/26/2001 | 18 | | 0.87 | 0.15 |

| USGS Gage Number | Sample Date | Flow (cfs) | TSS (mg/L) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|-----------------------------|--------------------|-----------------------|-----------------------|----------------------------------|------------------------------------|
| 6900100 | 5/24/2001 | 16 | 31 | 1.4 | 0.12 |
| 6900100 | 6/19/2001 | 17 | | 1.9 | 0.26 |
| 6900100 | 6/26/2001 | 13 | | 0.92 | 0.09 |
| 6900100 | 7/25/2001 | 11 | 444 | 4 | 0.48 |
| 6900100 | 8/8/2001 | 1.4 | | 0.59 | E 0.05 |
| 6900100 | 9/12/2001 | 1.2 | | 0.79 | 0.07 |
| 6900100 | 10/25/2001 | 7.5 | 54 | 2.2 | 0.2 |
| 6900100 | 11/28/2001 | 1.5 | < 10 | | < 0.06 |
| 6900100 | 12/12/2001 | 1.7 | < 10 | | < 0.06 |
| 6900100 | 1/8/2002 | 0.38 | < 10 | 0.8 | < 0.06 |
| 6900100 | 2/27/2002 | 1.8 | < 10 | 1.2 | E 0.03 |
| 6900100 | 3/19/2002 | 2 | < 10 | | < 0.06 |
| 6900100 | 4/17/2002 | 13 | 66 | 1 | 0.13 |
| 6900100 | 5/21/2002 | 9.1 | 14 | 0.67 | 0.07 |
| 6900100 | 6/28/2002 | 2 | < 10 | E 0.44 | E 0.04 |
| 6900100 | 7/24/2002 | 0.59 | < 10 | | E 0.04 |
| 6900100 | 8/21/2002 | 3.1 | < 10 | 0.62 | 0.1 |
| 6900100 | 9/10/2002 | 0.15 | < 10 | | E 0.04 |
| 6900100 | 10/17/2002 | 0.31 | < 10 | | E 0.03 |
| 6900100 | 11/19/2002 | 0.41 | < 10 | | 0.06 |
| 6900100 | 12/18/2002 | 0.64 | < 10 | | E 0.02 |
| 6900100 | 1/29/2003 | 0.11 | < 10 | | 0.05 |
| 6900100 | 2/20/2003 | 0.64 | < 10 | | E 0.03 |
| 6900100 | 3/12/2003 | 1.4 | < 10 | | < 0.04 |
| 6900100 | 4/23/2003 | 0.47 | < 10 | 0.61 | 0.04 |
| 6900100 | 5/8/2003 | 3.5 | 127 | 2.4 | 0.19 |
| 6900100 | 6/11/2003 | 30 | 344 | 5.4 | 0.51 |
| 6900100 | 7/10/2003 | 138 | E 2060 | 7.7 | 1.76 |
| 6900100 | 8/25/2003 | 0.08 | 13 | E 0.64 | 0.1 |
| 6900100 | 9/18/2003 | 0.48 | 20 | 0.65 | 0.07 |
| 6900100 | 10/22/2003 | 0.3 | < 10 | | 0.07 |
| 6900100 | 11/20/2003 | 0.52 | < 10 | | 0.05 |
| 6900100 | 12/10/2003 | 98 | 470 | 6.5 | 0.93 |
| 6900100 | 1/7/2004 | 0.73 | 16 | 2.2 | E 0.03 |
| 6900100 | 2/26/2004 | 10 | 36 | 2.2 | 0.11 |
| 6900100 | 3/16/2004 | 25 | 56 | 1.7 | 0.14 |
| 6900100 | 4/22/2004 | 4.6 | < 10 | | 0.04 |
| 6900100 | 5/13/2004 | 8.9 | 102 | 1.2 | 0.18 |
| 6900100 | 6/23/2004 | 12 | 33 | 1.3 | 0.13 |
| 6900100 | 7/14/2004 | 6 | 37 | 1.3 | 0.15 |
| 6900100 | 8/25/2004 | 2150 | 1400 | 5.8 | 1.91 |
| 6900100 | 9/16/2004 | 5.8 | 64 | 0.65 | 0.17 |
| 6900100 | 10/27/2004 | 16 | 146 | 1.3 | 0.29 |
| 6900100 | 11/18/2004 | 5.2 | < 10 | | E 0.04 |
| 6900100 | 12/17/2004 | 4.6 | < 10 | 0.85 | E 0.03 |
| 6900100 | 1/27/2005 | 24 | 51 | 2.6 | 0.37 |
| 6900100 | 2/10/2005 | 7 | 48 | 1.8 | 0.11 |

| USGS Gage Number | Sample Date | Flow (cfs) | TSS (mg/L) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|-----------------------------|--------------------|-----------------------|-----------------------|----------------------------------|------------------------------------|
| 6900100 | 3/16/2005 | 7.6 | < 10 | | 0.04 |
| 6900100 | 4/8/2005 | 15 | 18 | | 0.07 |
| 6900100 | 5/12/2005 | 8.6 | 38 | E 0.66 | 0.1 |
| 6900100 | 6/30/2005 | 6 | 20 | E 0.73 | 0.1 |
| 6900100 | 7/12/2005 | 1.4 | < 10 | E 0.53 | 0.06 |
| 6900100 | 8/17/2005 | 0.42 | < 10 | 0.64 | 0.06 |
| 6900100 | 9/20/2005 | 0.64 | < 10 | | 0.05 |
| 6900100 | 10/5/2005 | 0.22 | < 10 | E 0.29 | E 0.04 |
| 6900100 | 11/2/2005 | 0.15 | < 10 | | 0.05 |
| 6900100 | 12/15/2005 | 1.6 | < 10 | | E 0.03 |
| 6900100 | 1/26/2006 | 0.73 | < 10 | | E 0.03 |
| 6900100 | 2/17/2006 | 0.37 | < 10 | | E 0.04 |
| 6900100 | 3/8/2006 | 2.2 | < 10 | | 0.04 |
| 6900100 | 4/13/2006 | 1.5 | 15 | | 0.07 |
| 6900100 | 5/10/2006 | 2.3 | 19 | | 0.05 |
| 6900100 | 6/14/2006 | 0.43 | < 10 | 0.53 | 0.05 |
| 6900100 | 7/19/2006 | 0.22 | < 10 | 0.79 | 0.08 |
| 6900100 | 8/9/2006 | 3 | 122 | 1.2 | 0.25 |
| 6900100 | 9/20/2006 | 0.16 | < 10 | | E 0.03 |
| 6900100 | 10/24/2006 | 0.35 | < 10 | | 0.06 |
| 6900100 | 11/16/2006 | 0.45 | < 10 | | 0.09 |
| 6900100 | 12/14/2006 | 1.1 | 13 | 1.5 | 0.06 |
| 6900100 | 1/25/2007 | 2.2 | < 10 | 1.2 | < 0.04 |
| 6900100 | 2/21/2007 | E 130 | 59 | 6.2 | 1.16 |
| 6900100 | 3/15/2007 | 14 | 64 | 1.8 | 0.13 |
| 6900100 | 4/25/2007 | 1830 | 1070 | 7.3 | 2.42 |
| 6900100 | 5/10/2007 | 52 | 184 | 2.3 | 0.33 |
| 6900100 | 6/27/2007 | 1.4 | 10 | 0.56 | 0.06 |
| 6900100 | 7/18/2007 | 0.53 | 13 | | 0.06 |
| 6900100 | 8/21/2007 | 14 | 663 | 5.6 | 0.92 |
| 6900100 | 9/25/2007 | 1.5 | < 20 | E 0.43 | 0.09 |
| 6900100 | 10/17/2007 | 13 | 424 | 2.2 | 0.81 |
| 6900100 | 11/8/2007 | 1 | < 10 | | 0.1 |
| 6900100 | 12/19/2007 | 13 | 31 | 2.2 | 0.15 |
| 6900100 | 1/10/2008 | 68 | 88 | 2.7 | 0.34 |
| 6900100 | 2/27/2008 | 58 | 82 | 3.2 | 0.37 |
| 6900100 | 3/26/2008 | 21 | 43 | 0.95 | 0.11 |
| 6900100 | 4/16/2008 | 33 | 88 | 1.4 | 0.21 |
| 6900100 | 5/21/2008 | 7.3 | < 10 | | 0.08 |
| 6900100 | 6/18/2008 | 20 | 74 | 1.3 | 0.21 |
| 6900100 | 7/16/2008 | 3 | 10 | 0.51 | 0.07 |
| 6900100 | 8/13/2008 | 3.3 | 13 | 0.48 | 0.08 |
| 6900100 | 9/24/2008 | 300 | 2200 | 5.7 | 1.81 |
| 6900100 | 10/29/2008 | 18 | 23 | 0.65 | 0.11 |
| 6900100 | 11/19/2008 | 30 | 33 | 1 | 0.11 |
| 6900100 | 12/3/2008 | 17 | < 15 | 0.68 | 0.05 |
| 6900100 | 1/28/2009 | 4.5 | < 15 | 0.73 | E 0.03 |

| USGS Gage Number | Sample Date | Flow (cfs) | TSS (mg/L) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|--------------------------------------|--------------------|-----------------------|-----------------------|----------------------------------|------------------------------------|
| 6900100 | 2/25/2009 | 12 | 18 | 0.57 | 0.05 |
| 6900100 | 3/11/2009 | 118 | 490 | 3.4 | 0.56 |
| 6900100 | 4/22/2009 | 15 | 15 | 0.41 | 0.06 |
| 6900100 | 5/13/2009 | 352 | 1760 | 7.8 | 2.21 |
| 6900100 | 6/24/2009 | 26 | 160 | 2 | 0.29 |
| 6900100 | 7/22/2009 | 2.5 | < 15 | 0.47 | 0.05 |
| 6900100 | 8/20/2009 | 176 | 1290 | 3.8 | 1.15 |
| Locust Creek near Linneus, MO | | | | | |
| 6901500 | 8/26/2003 | 0.8 | <10 | | 0.05 |
| Grand River near Sumner, MO | | | | | |
| 6902000 | 11/8/1989 | 373 | | 1 | 0.13 |
| 6902000 | 1/18/1990 | 851 | | 2.2 | 0.34 |
| 6902000 | 5/9/1990 | 5480 | | 2.3 | 0.42 |
| 6902000 | 7/11/1990 | 1430 | | 1.3 | 0.35 |
| 6902000 | 11/7/1990 | 1310 | | 3.6 | 0.3 |
| 6902000 | 1/9/1991 | 452 | | 2 | 0.24 |
| 6902000 | 5/17/1991 | 14200 | | 2.6 | 0.39 |
| 6902000 | 7/16/1991 | 2510 | | 3.2 | 0.41 |
| 6902000 | 11/6/1991 | 470 | | 1.7 | 0.31 |
| 6902000 | 1/15/1992 | 2720 | | 1.7 | 0.34 |
| 6902000 | 7/8/1992 | 340 | | | 0.11 |
| 6902000 | 11/12/1992 | 7780 | | 2.2 | 0.22 |
| 6902000 | 12/2/1992 | 4980 | | 1.4 | 0.28 |
| 6902000 | 1/6/1993 | 8980 | | 1.9 | 0.47 |
| 6902000 | 2/17/1993 | 2510 | | 1.4 | 0.25 |
| 6902000 | 3/17/1993 | 3220 | | 1.5 | 0.28 |
| 6902000 | 4/8/1993 | 29800 | | 1.5 | 0.22 |
| 6902000 | 5/12/1993 | 33700 | | 3.7 | 0.2 |
| 6902000 | 6/16/1993 | 18400 | | 11 | 1 |
| 6902000 | 7/27/1993 | 128000 | | 2.1 | 0.55 |
| 6902000 | 8/25/1993 | 2820 | | 1.3 | |
| 6902000 | 9/16/1993 | 23600 | | 2.8 | 0.34 |
| 6902000 | 10/27/1993 | 1700 | | 1.1 | 0.04 |
| 6902000 | 11/16/1993 | 3300 | | 1.7 | 0.25 |
| 6902000 | 12/8/1993 | 1140 | | | 0.03 |
| 6902000 | 1/5/1994 | 755 | | 0.92 | 0.05 |
| 6902000 | 2/3/1994 | 1200 | | 2.7 | 0.18 |
| 6902000 | 3/16/1994 | 1750 | | 1.8 | 0.18 |
| 6902000 | 3/30/1994 | 750 | | 0.78 | 0.09 |
| 6902000 | 4/27/1994 | 900 | | | 0.12 |
| 6902000 | 5/10/1994 | 3700 | | 2.6 | 0.28 |
| 6902000 | 6/14/1994 | 4500 | | 5.2 | 1.2 |
| 6902000 | 8/23/1994 | 250 | | | |
| 6902000 | 9/14/1994 | 270 | | | 0.11 |
| 6902000 | 10/26/1994 | 136 | | | 0.13 |
| 6902000 | 11/30/1994 | 1200 | | 2 | 0.15 |
| 6902000 | 12/14/1994 | 1140 | | 1.8 | 0.2 |

| USGS Gage Number | Sample Date | Flow (cfs) | TSS (mg/L) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|-----------------------------|--------------------|-----------------------|-----------------------|----------------------------------|------------------------------------|
| 6902000 | 1/5/1995 | 350 | | 1.4 | 0.03 |
| 6902000 | 2/8/1995 | 2060 | | 2.7 | 0.27 |
| 6902000 | 3/30/1995 | 2720 | | 3.5 | 0.13 |
| 6902000 | 4/18/1995 | 5660 | | 7.9 | 0.41 |
| 6902000 | 5/24/1995 | 51600 | | 2.8 | 0.4 |
| 6902000 | 6/14/1995 | 4450 | | 1.5 | 0.2 |
| 6902000 | 7/12/1995 | 6100 | | 2.8 | 0.14 |
| 6902000 | 8/2/1995 | 2030 | | 1.8 | 0.39 |
| 6902000 | 9/5/1995 | 496 | | | 0.13 |
| 6902000 | 10/24/1995 | 235 | | | 0.11 |
| 6902000 | 11/6/1995 | 595 | | 1.2 | 0.1 |
| 6902000 | 12/13/1995 | 216 | | 0.49 | 0.04 |
| 6902000 | 1/22/1996 | 430 | | 1.1 | 0.08 |
| 6902000 | 2/14/1996 | 3050 | | 2.5 | 1 |
| 6902000 | 3/26/1996 | 1480 | | 2.4 | 0.31 |
| 6902000 | 4/16/1996 | 520 | | | 0.16 |
| 6902000 | 5/20/1996 | 4660 | | 3.6 | 0.57 |
| 6902000 | 6/19/1996 | 14500 | | 4.8 | 0.83 |
| 6902000 | 7/17/1996 | 1050 | | | 0.16 |
| 6902000 | 8/14/1996 | 906 | | | 0.12 |
| 6902000 | 9/11/1996 | 1170 | | 1.6 | 0.14 |
| 6902000 | 10/9/1996 | 527 | | | 0.1 |
| 6902000 | 11/20/1996 | 4930 | | 3.3 | 0.18 |
| 6902000 | 1/22/1997 | 466 | | 1.4 | 0.07 |
| 6902000 | 2/12/1997 | 1620 | | 2.2 | 0.16 |
| 6902000 | 3/17/1997 | 2510 | | 1.7 | 0.28 |
| 6902000 | 4/23/1997 | 29800 | | 4.6 | 0.28 |
| 6902000 | 5/27/1997 | 2130 | | E 2.9 | 0.44 |
| 6902000 | 6/17/1997 | 15100 | | 5.2 | 0.25 |
| 6902000 | 7/29/1997 | 395 | | | 0.12 |
| 6902000 | 8/19/1997 | 511 | | 0.98 | 0.18 |
| 6902000 | 9/9/1997 | 286 | | 1.2 | 0.15 |
| 6902000 | 11/17/1997 | 415 | 6 | | |
| 6902000 | 1/15/1998 | 1590 | 16 | | |
| 6902000 | 6/9/1998 | 4290 | 452 | | |
| 6902000 | 8/18/1998 | 587 | 60 | | |
| 6902000 | 11/16/1998 | 4640 | 264 | 1.3 | 0.15 |
| 6902000 | 12/1/1998 | 6620 | | 2.4 | 0.8 |
| 6902000 | 1/25/1999 | 4150 | 231 | 2.4 | 0.31 |
| 6902000 | 2/23/1999 | 3040 | | 1.2 | 0.16 |
| 6902000 | 3/23/1999 | 2740 | | 3.2 | 0.25 |
| 6902000 | 4/13/1999 | 3460 | | 2.5 | 0.47 |
| 6902000 | 5/19/1999 | 31900 | | 2.5 | 0.7 |
| 6902000 | 6/15/1999 | 6840 | 1800 | | |
| 6902000 | 7/27/1999 | 429 | | | 0.17 |
| 6902000 | 8/10/1999 | 639 | 80 | | 0.22 |
| 6902000 | 9/13/1999 | 365 | | | 0.21 |

| USGS Gage Number | Sample Date | Flow (cfs) | TSS (mg/L) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|-----------------------------|--------------------|-----------------------|-----------------------|----------------------------------|------------------------------------|
| 6902000 | 10/26/1999 | 130 | | | 0.1 |
| 6902000 | 11/30/1999 | 240 | 10 | | < 0.05 |
| 6902000 | 12/21/1999 | 157 | | 0.83 | 0.06 |
| 6902000 | 1/4/2000 | 198 | 16 | 0.75 | 0.07 |
| 6902000 | 2/1/2000 | 123 | | 0.61 | 0.05 |
| 6902000 | 3/7/2000 | 565 | | 1.7 | 0.27 |
| 6902000 | 4/3/2000 | 301 | | 0.83 | 0.19 |
| 6902000 | 5/2/2000 | 308 | 95 | | 0.22 |
| 6902000 | 6/12/2000 | 217 | | | 0.22 |
| 6902000 | 7/11/2000 | 924 | 180 | 1.3 | 0.32 |
| 6902000 | 8/2/2000 | 465 | | | 0.23 |
| 6902000 | 9/12/2000 | 129 | | | 0.22 |
| 6902000 | 10/2/2000 | 341 | | | 0.28 |
| 6902000 | 11/21/2000 | 220 | 12 | 1.2 | 0.08 |
| 6902000 | 12/5/2000 | 207 | | 1.3 | 0.08 |
| 6902000 | 1/3/2001 | E 203 | < 10 | 1.5 | E 0.03 |
| 6902000 | 2/14/2001 | 5880 | | 3.3 | 0.53 |
| 6902000 | 3/6/2001 | 8040 | | 3.8 | 0.79 |
| 6902000 | 4/17/2001 | 7800 | | 3 | 0.76 |
| 6902000 | 5/1/2001 | 1740 | 90 | | 0.22 |
| 6902000 | 6/19/2001 | 6690 | | 4.7 | 1.33 |
| 6902000 | 7/10/2001 | 1830 | 174 | 1.2 | 0.26 |
| 6902000 | 8/13/2001 | 572 | | | 0.17 |
| 6902000 | 9/5/2001 | 404 | | | 0.17 |
| 6902000 | 10/17/2001 | 3210 | 555 | 2.4 | 0.65 |
| 6902000 | 11/6/2001 | 416 | 18 | | 0.1 |
| 6902000 | 12/4/2001 | 323 | 16 | 0.46 | 0.12 |
| 6902000 | 1/8/2002 | 179 | < 10 | 0.61 | E 0.05 |
| 6902000 | 2/5/2002 | 347 | 12 | 0.95 | 0.08 |
| 6902000 | 3/6/2002 | 573 | 12 | 0.99 | E 0.05 |
| 6902000 | 4/10/2002 | 4220 | 1440 | 3.8 | 1.16 |
| 6902000 | 5/7/2002 | 43700 | 2420 | 9.1 | 3.12 |
| 6902000 | 6/10/2002 | 841 | | | 0.2 |
| 6902000 | 7/16/2002 | 393 | 145 | 1.8 | 0.54 |
| 6902000 | 8/13/2002 | 175 | < 10 | | 0.17 |
| 6902000 | 9/4/2002 | 145 | 65 | | 0.18 |
| 6902000 | 10/22/2002 | 97 | 39 | | 0.11 |
| 6902000 | 11/27/2002 | 115 | 10 | | 0.07 |
| 6902000 | 12/12/2002 | 102 | < 10 | 0.45 | 0.05 |
| 6902000 | 2/12/2003 | 121 | < 10 | 1.3 | 0.06 |
| 6902000 | 2/25/2003 | E 130 | < 10 | 0.52 | 0.08 |
| 6902000 | 3/21/2003 | 354 | 29 | 0.9 | 0.09 |
| 6902000 | 4/11/2003 | 163 | 46 | | 0.12 |
| 6902000 | 5/2/2003 | 1940 | 524 | 3.3 | 0.76 |
| 6902000 | 6/20/2003 | 516 | 114 | 2 | 0.28 |
| 6902000 | 7/29/2003 | 130 | 19 | | 0.19 |
| 6902000 | 8/21/2003 | 66 | 81 | | 0.23 |

| USGS Gage Number | Sample Date | Flow (cfs) | TSS (mg/L) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|-----------------------------|--------------------|-----------------------|-----------------------|----------------------------------|------------------------------------|
| 6902000 | 9/9/2003 | 85 | 58 | | 0.18 |
| 6902000 | 10/21/2003 | 96 | 44 | | 0.2 |
| 6902000 | 11/5/2003 | 75 | 26 | | 0.09 |
| 6902000 | 12/15/2003 | 888 | 89 | 3.1 | 0.32 |
| 6902000 | 1/7/2004 | E 275 | < 10 | 1.6 | 0.08 |
| 6902000 | 2/3/2004 | E 165 | < 10 | 1.4 | 0.08 |
| 6902000 | 3/2/2004 | 997 | 112 | 2.8 | 0.26 |
| 6902000 | 4/6/2004 | 2040 | 136 | 2.4 | 0.25 |
| 6902000 | 5/19/2004 | 21000 | 1070 | 8.8 | 2.37 |
| 6902000 | 6/28/2004 | 1910 | 158 | 1.3 | 0.28 |
| 6902000 | 7/15/2004 | 7510 | 475 | 3.8 | 1.22 |
| 6902000 | 8/16/2004 | 715 | 49 | | 0.19 |
| 6902000 | 9/2/2004 | E 125000 | 543 | 1.7 | 0.57 |
| 6902000 | 10/12/2004 | 900 | 132 | 1.3 | 0.26 |
| 6902000 | 11/9/2004 | 1410 | 56 | 0.93 | 0.17 |
| 6902000 | 12/1/2004 | 813 | 22 | 0.86 | 0.11 |
| 6902000 | 1/24/2005 | 1530 | 90 | 1.8 | 0.22 |
| 6902000 | 2/14/2005 | 55000 | 2160 | 6.4 | 1.83 |
| 6902000 | 3/8/2005 | 1460 | 43 | 1.2 | 0.12 |
| 6902000 | 4/4/2005 | 992 | 55 | | 0.11 |
| 6902000 | 5/3/2005 | 1530 | 117 | 1.7 | 0.21 |
| 6902000 | 6/22/2005 | 1600 | 203 | 1.8 | 0.34 |
| 6902000 | 7/12/2005 | 513 | 135 | | 0.26 |
| 6902000 | 8/22/2005 | 909 | 252 | 1.9 | 0.41 |
| 6902000 | 9/7/2005 | 301 | 55 | | 0.18 |
| 6902000 | 10/12/2005 | 315 | 34 | 1.1 | 0.12 |
| 6902000 | 11/2/2005 | 220 | < 10 | 0.54 | 0.07 |
| 6902000 | 12/19/2005 | 272 | < 10 | 1 | 0.04 |
| 6902000 | 1/4/2006 | 459 | 14 | 1.1 | 0.07 |
| 6902000 | 2/7/2006 | 357 | < 10 | 0.79 | 0.07 |
| 6902000 | 3/7/2006 | 267 | 12 | E 0.44 | 0.07 |
| 6902000 | 4/10/2006 | 1010 | 415 | 2.7 | 0.53 |
| 6902000 | 5/3/2006 | 12500 | 1180 | 7.1 | 1.48 |
| 6902000 | 6/21/2006 | 386 | 154 | | 0.3 |
| 6902000 | 7/6/2006 | 259 | 41 | | 0.2 |
| 6902000 | 8/2/2006 | 131 | 138 | | 0.23 |
| 6902000 | 9/6/2006 | 432 | 170 | | 0.34 |
| 6902000 | 10/10/2006 | 121 | 51 | | 0.1 |
| 6902000 | 11/6/2006 | 289 | 43 | 1.2 | 0.15 |
| 6902000 | 12/5/2006 | 546 | 76 | 2.8 | 0.26 |
| 6902000 | 1/4/2007 | 3400 | 767 | 4.9 | 1.05 |
| 6902000 | 2/14/2007 | 272 | < 10 | 1.6 | 0.05 |
| 6902000 | 3/7/2007 | 3450 | 258 | 3.4 | 0.48 |
| 6902000 | 4/3/2007 | 7510 | 1120 | 3.9 | 1.1 |
| 6902000 | 5/2/2007 | 4620 | 360 | 3.4 | 0.51 |
| 6902000 | 6/6/2007 | 4600 | 200 | 3.1 | 0.43 |
| 6902000 | 7/10/2007 | 447 | 104 | | 0.2 |

| USGS Gage Number | Sample Date | Flow (cfs) | TSS (mg/L) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|------------------------------------|--------------------|-----------------------|-----------------------|----------------------------------|------------------------------------|
| 6902000 | 8/14/2007 | 1230 | 242 | 2 | 0.37 |
| 6902000 | 9/11/2007 | 736 | 52 | | 0.17 |
| 6902000 | 10/23/2007 | 3100 | 340 | 2.9 | 0.6 |
| 6902000 | 11/6/2007 | 569 | 27 | 1.5 | 0.12 |
| 6902000 | 12/4/2007 | 702 | 45 | 0.84 | 0.14 |
| 6902000 | 1/9/2008 | 16000 | 850 | 3.9 | 1.11 |
| 6902000 | 2/14/2008 | 1900 | 100 | 1.9 | 0.22 |
| 6902000 | 3/5/2008 | 50600 | 1180 | 3.9 | 1.43 |
| 6902000 | 4/16/2008 | 7050 | 144 | 2.8 | 0.64 |
| 6902000 | 6/2/2008 | 10700 | 1120 | 5.1 | 1.31 |
| 6902000 | 7/9/2008 | 4230 | 384 | 1.8 | 0.49 |
| 6902000 | 8/4/2008 | 8200 | 452 | 1.7 | 0.47 |
| 6902000 | 9/2/2008 | 803 | 80 | | 0.16 |
| 6902000 | 10/21/2008 | 1940 | 106 | 1.4 | 0.27 |
| 6902000 | 11/24/2008 | 2600 | 75 | 1.1 | 0.15 |
| 6902000 | 12/9/2008 | 1500 | 48 | 0.94 | 0.11 |
| 6902000 | 2/2/2009 | 1080 | < 15 | 1 | 0.06 |
| 6902000 | 3/10/2009 | 57300 | 1300 | 5.9 | 1.77 |
| 6902000 | 4/1/2009 | 10900 | 418 | 2.3 | 0.55 |
| 6902000 | 5/5/2009 | 8690 | 780 | 2.5 | 0.68 |
| 6902000 | 6/2/2009 | 3960 | 312 | 2.9 | 0.42 |
| 6902000 | 7/28/2009 | 986 | 62 | | 0.18 |
| 6902000 | 8/17/2009 | 46900 | 1790 | 3.9 | 1.52 |
| 6902000 | 9/1/2009 | 6300 | 454 | 1.7 | 0.53 |
| Mussel Fork near Mystic, MO | | | | | |
| 6905725 | 1/23/1998 | 1.6 | 12 | | |
| 6905725 | 6/3/1998 | 1.2 | 22 | | |
| 6905725 | 1/6/1999 | 1.9 | 4 | 0.56 | < 0.05 |
| 6905725 | 3/31/1999 | 2.4 | | 0.54 | E 0.04 |
| 6905725 | 4/21/1999 | 8.4 | | 0.98 | 0.11 |
| 6905725 | 6/23/1999 | 0.54 | 47 | 0.89 | 0.09 |
| 6905725 | 10/25/1999 | 0.01 | | | 0.07 |
| 6905725 | 11/30/1999 | 0.01 | 11 | | 0.05 |
| 6905725 | 12/20/1999 | 0.1 | | | < 0.05 |
| 6905725 | 1/24/2000 | 0.1 | 24 | | 0.05 |
| 6905725 | 4/20/2000 | 0.16 | | | 0.07 |
| 6905725 | 5/11/2000 | 0.07 | < 10 | | 0.07 |
| 6905725 | 6/14/2000 | 8.3 | | 3.3 | 0.44 |
| 6905725 | 6/15/2000 | 7.3 | | 2.7 | 0.25 |
| 6905725 | 6/20/2000 | 0.22 | | 1.9 | 0.11 |
| 6905725 | 7/27/2000 | 0 | 10 | | E 0.04 |
| 6905725 | 10/25/2000 | 0.03 | | | 0.28 |
| 6905725 | 11/15/2000 | 0.1 | < 10 | | 0.08 |
| 6905725 | 12/20/2000 | 0.02 | | | 0.06 |
| 6905725 | 1/24/2001 | 0.24 | 10 | 4.3 | 0.17 |
| 6905725 | 2/14/2001 | 59 | | 3.2 | 0.42 |
| 6905725 | 3/28/2001 | 4.3 | | 2.2 | 0.12 |

| USGS Gage Number | Sample Date | Flow (cfs) | TSS (mg/L) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|-----------------------------|--------------------|-----------------------|-----------------------|----------------------------------|------------------------------------|
| 6905725 | 4/25/2001 | 4.1 | | | 0.12 |
| 6905725 | 5/22/2001 | 1.1 | | 1.1 | 0.08 |
| 6905725 | 5/23/2001 | 0.82 | 11 | 1.1 | 0.08 |
| 6905725 | 6/18/2001 | 7.6 | | 1.4 | 0.21 |
| 6905725 | 6/28/2001 | 2.5 | | | 0.11 |
| 6905725 | 7/26/2001 | 4.8 | 228 | 4.7 | 0.4 |
| 6905725 | 8/9/2001 | 0.13 | | E 1.1 | 0.1 |
| 6905725 | 9/11/2001 | 0.03 | | E 1.1 | 0.1 |
| 6905725 | 10/24/2001 | 3.5 | 50 | 2.4 | 0.42 |
| 6905725 | 11/29/2001 | 0.17 | < 10 | | E 0.06 |
| 6905725 | 12/13/2001 | 0.83 | 20 | | E 0.05 |
| 6905725 | 1/9/2002 | 0.2 | 10 | 0.97 | E 0.05 |
| 6905725 | 2/28/2002 | 1.4 | 18 | 1.4 | 0.09 |
| 6905725 | 3/20/2002 | 0.97 | < 10 | | E 0.04 |
| 6905725 | 4/18/2002 | 1.6 | 17 | | 0.07 |
| 6905725 | 5/22/2002 | 2.2 | 20 | | 0.12 |
| 6905725 | 6/27/2002 | 0.06 | 10 | E 0.69 | E 0.04 |
| 6905725 | 8/22/2002 | 0.17 | 22 | E 0.77 | 0.08 |
| 6905725 | 2/21/2003 | 0.05 | < 10 | 1.7 | 0.15 |
| 6905725 | 3/13/2003 | 2.5 | 37 | | 0.2 |
| 6905725 | 3/19/2003 | 0.3 | 14 | E 1.7 | 0.14 |
| 6905725 | 4/24/2003 | 0.19 | 26 | 1.9 | 0.1 |
| 6905725 | 4/30/2003 | 1.9 | 32 | 2.2 | 0.2 |
| 6905725 | 5/7/2003 | 2.5 | 44 | 2.1 | 0.23 |
| 6905725 | 6/12/2003 | 0.72 | 16 | E 1.2 | 0.09 |
| 6905725 | 7/9/2003 | E 0.00 | 11 | | 0.1 |
| 6905725 | 9/17/2003 | 0.33 | 15 | 1.7 | 0.14 |
| 6905725 | 11/19/2003 | E 0.01 | 38 | | 0.27 |
| 6905725 | 12/11/2003 | 7.9 | 84 | 5 | 0.41 |
| 6905725 | 1/8/2004 | 0.24 | 19 | 2.1 | 0.17 |
| 6905725 | 2/20/2004 | 41 | 81 | 3.5 | 0.52 |
| 6905725 | 3/17/2004 | 25 | 60 | 1.8 | 0.18 |
| 6905725 | 4/21/2004 | 1.6 | 15 | | 0.06 |
| 6905725 | 5/12/2004 | 0.55 | < 10 | | 0.07 |
| 6905725 | 6/24/2004 | 1.9 | 31 | 1.6 | 0.21 |
| 6905725 | 7/13/2004 | 11 | 52 | 1.6 | 0.21 |
| 6905725 | 8/24/2004 | 0.25 | 21 | 1.1 | 0.07 |
| 6905725 | 9/15/2004 | 0.52 | < 10 | E 1.1 | 0.09 |
| 6905725 | 10/28/2004 | 2 | < 10 | | 0.14 |
| 6905725 | 11/17/2004 | 1.8 | < 10 | 0.67 | 0.06 |
| 6905725 | 12/17/2004 | 2.4 | < 10 | 0.71 | 0.05 |
| 6905725 | 1/26/2005 | 18 | 46 | 1.8 | 0.22 |
| 6905725 | 2/8/2005 | 22 | 65 | 2.6 | 0.18 |
| 6905725 | 3/17/2005 | 2.9 | < 10 | | 0.13 |
| 6905725 | 4/7/2005 | 2.9 | < 10 | | 0.06 |
| 6905725 | 5/11/2005 | 11 | 10 | | 0.07 |
| 6905725 | 6/29/2005 | 1.7 | 21 | | 0.08 |

| USGS Gage Number | Sample Date | Flow (cfs) | TSS (mg/L) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|-----------------------------|--------------------|-----------------------|-----------------------|----------------------------------|------------------------------------|
| 6905725 | 7/14/2005 | 0.02 | < 10 | | 0.04 |
| 6905725 | 8/18/2005 | 0.08 | 22 | E 1.8 | 0.12 |
| 6905725 | 9/21/2005 | 0.05 | 74 | | 0.23 |
| 6905725 | 10/4/2005 | 0.9 | 316 | 4.2 | 0.59 |
| 6905725 | 11/1/2005 | 0.04 | 22 | | 0.16 |
| 6905725 | 12/13/2005 | 0.01 | < 10 | | 0.06 |
| 6905725 | 1/27/2006 | 0.12 | < 10 | | 0.05 |
| 6905725 | 2/15/2006 | 0.17 | 15 | 2.9 | 0.07 |
| 6905725 | 3/9/2006 | 0.3 | < 10 | | 0.04 |
| 6905725 | 4/14/2006 | 1.3 | 18 | | 0.08 |
| 6905725 | 5/12/2006 | 1.1 | 10 | | 0.07 |
| 6905725 | 6/15/2006 | 0.11 | < 10 | | 0.06 |
| 6905725 | 7/17/2006 | 0 | 34 | 1.5 | 0.15 |
| 6905725 | 8/8/2006 | 2.4 | 203 | 1.9 | 0.36 |
| 6905725 | 9/21/2006 | 0.06 | 11 | 1.1 | 0.06 |
| 6905725 | 10/23/2006 | 0.03 | 20 | 2.1 | 0.14 |
| 6905725 | 11/15/2006 | 0.03 | 82 | | 0.2 |
| 6905725 | 12/15/2006 | 0.2 | < 10 | 0.95 | 0.1 |
| 6905725 | 1/24/2007 | 0.62 | 11 | 1 | 0.1 |
| 6905725 | 2/22/2007 | 8 | < 10 | 4.4 | 0.58 |
| 6905725 | 3/13/2007 | 6.5 | 25 | 2.3 | 0.17 |
| 6905725 | 4/24/2007 | 1.7 | < 50 | | 0.08 |
| 6905725 | 5/8/2007 | 74 | 176 | 2 | 0.36 |
| 6905725 | 6/28/2007 | 12 | 444 | 5.6 | 0.6 |
| 6905725 | 7/17/2007 | 0.06 | 26 | | 0.08 |
| 6905725 | 8/22/2007 | 2.5 | 245 | 3.5 | 0.53 |
| 6905725 | 9/26/2007 | 0.04 | 54 | | 0.18 |
| 6905725 | 10/17/2007 | 0.07 | 312 | 1.9 | 0.37 |
| 6905725 | 11/7/2007 | 0.05 | 11 | | 0.16 |
| 6905725 | 12/18/2007 | 2.8 | 20 | 2.5 | 0.2 |
| 6905725 | 1/9/2008 | 40 | 68 | 3.1 | 0.28 |
| 6905725 | 2/26/2008 | 39 | 180 | 3.1 | 0.57 |
| 6905725 | 3/25/2008 | 6.2 | 21 | 1.4 | 0.1 |
| 6905725 | 4/17/2008 | 5.8 | 28 | 1.1 | 0.11 |
| 6905725 | 5/22/2008 | 1.2 | 10 | | 0.07 |
| 6905725 | 6/19/2008 | 2.5 | 25 | 1.5 | 0.15 |
| 6905725 | 7/18/2008 | 0.4 | 16 | | 0.1 |
| 6905725 | 8/14/2008 | 3.9 | 182 | 1.9 | 0.28 |
| 6905725 | 9/23/2008 | 2.1 | 14 | | 0.12 |
| 6905725 | 10/28/2008 | 1.5 | < 15 | 1.3 | 0.12 |
| 6905725 | 11/20/2008 | 4.8 | < 15 | 1.3 | 0.1 |
| 6905725 | 12/4/2008 | 3.5 | < 15 | 0.6 | 0.05 |
| 6905725 | 1/29/2009 | 0.89 | < 15 | 0.62 | 0.06 |
| 6905725 | 2/26/2009 | 4.8 | < 15 | 0.62 | 0.05 |
| 6905725 | 3/12/2009 | 25 | 170 | 2.3 | 0.28 |
| 6905725 | 4/23/2009 | 5.4 | < 15 | E 0.64 | 0.07 |
| 6905725 | 5/14/2009 | 47 | 214 | 2.4 | 0.34 |

| USGS Gage Number | Sample Date | Flow (cfs) | TSS (mg/L) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|-----------------------------|--------------------|-----------------------|-----------------------|----------------------------------|------------------------------------|
| 6905725 | 6/26/2009 | 5 | < 150 | 1.8 | 0.16 |
| 6905725 | 7/21/2009 | 0.32 | < 15 | | 0.05 |
| 6905725 | 8/19/2009 | 2 | 106 | 2.1 | 0.23 |